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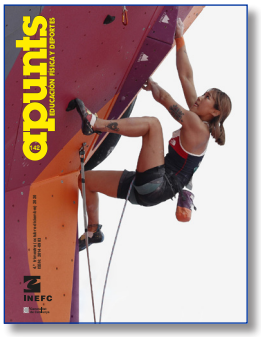

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Relationship between Strength and Self-Perception of Independence in Activities of Daily Living of Paraplegic Adults

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New Olimpic Sports for Tokyo 2020. Climbing. Photo: Climbing. Asian Games 2018. Women's combined final. Competes Kim Ja-in from South Korea. Climbing leader. JSC Sport Climbing. Palembang, Indonesia. REUTERS / Edgar Su.

Abstract

The objective of this study was to examine whether there was a relationship between relative strength development and self-perception of independence in adults with paraplegia six weeks after a physical activity intervention. For this purpose, a sample of eight people with paraplegia was evaluated, five men and three women, with a mean age of 29.5 ±5.17 years, with spinal cord injury below D5, and who had not performed physical activity previously. The relative strength index was used to measure body capacity together with the Barthel index questionnaire to evaluate independence in activities of daily living. The results showed a very high significant Pearson's correlation coefficient between changes in relative strength and the questionnaire (.93), as well as an 87.1 % coefficient of determination. The mean percentage increase in the participants' relative strength was 25.52 %, accompanied by a 16.54 % increase in the questionnaire score. In conclusion, there was a direct relationship between relative strength and the self-perception of adults with paraplegia of their independence in daily life, which shows that an intervention programme leads to significant changes in relative strength and self-perception of independence.

Keywords: spinal cord injury, physical disability, independence, evaluation, exercise.

Introduction

In general terms there are various benefits of engaging in physical activity for people with disabilities (Gallego et al., 2016), such as improved self-concept and independence. These benefits are also observed in paraplegia (Kawanishi & Greguol, 2013) and these factors are essential for devising social inclusion strategies for people with physical disabilities (Macías García & González López, 2012). Accordingly, this study contends that adapted physical activity has been conceived as a means of rehabilitation, and there are several studies which examine features related to performance (Castelli Correia de Campos et al., 2019) and quality of life.

Some papers report that upper body strength is crucial in the activities of daily living of people with paraplegia (Gottlob, 2008), although there are almost no studies about the impact of relative strength on the self-perception of independence in activities of daily living of people with paraplegia.

There is little scientific evidence relating relative strength and the perception of independence. In this respect, relative strength means the ability to lift and accelerate body movement (National Strength and Conditioning Association, NSCA). Similarly, Barrero, García-Arrioja and Ojeda (2005) define self-perception of independence as a person's own assessment of their functional capacity in their activities of daily living.

A previous study (Jiménez, Martín, Abadía, & Herrero, 2007) presents similarities with the purpose of this paper by establishing the influence of strength endurance on physical condition in individuals with spinal cord injuries in wheelchairs between the ages of 22 and 39, where strength is a basic physical ability which, in addition to the biological domain, may also affect other areas of people's lives (Kawanishi & Greguol, 2013). In all these cases, strength is said to be related to physical self-concept.

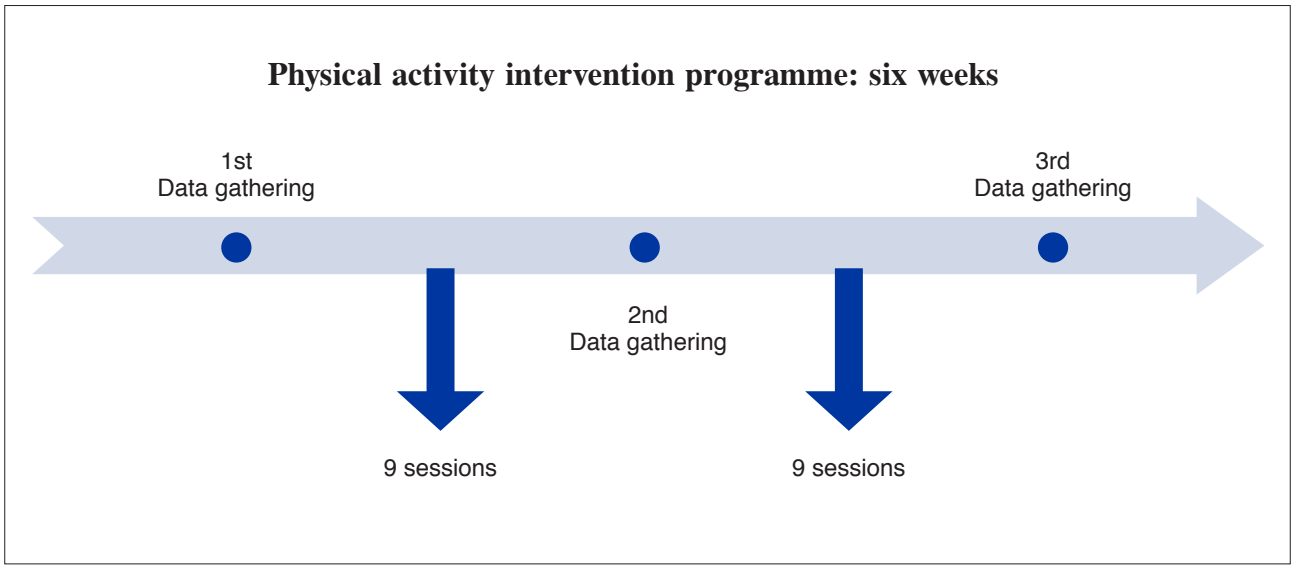
In terms of independence, Penninx et al. (2001) describe a study comparing the development of strength with independence and the prevention of acquired disability. However, in their conclusions they argue that endurance, rather than strength, is the basic physical capacity which can grant independence and prevent disability. There are also studies (Martins, Alberto, & Massoli, 2019) that show the impact of ergonomics on the performance of an activity in people with physical disabilities.

As for the potential impact of strength endurance on relative strength, Jiménez et al. (2007) hold that strength endurance cannot alter maximal strength and therefore cannot alter relative strength either. A distinction is drawn between maximal strength and relative strength, whereby the latter is determined by dividing the kilos lifted at maximal strength by the kilos of the individual's body weight (Bompa, 2003). It is germane to underline this, since the programme to be used in this study would not see changes in either maximal or relative strength. Thus, the relationship between psychological and social factors is significant when the impact of this basic physical capacity on aspects of wellbeing and functionality (Serra, 2011) is considered. However, hitherto, relative strength has not been shown to be related to self-perception of independence.

Moreover, since previous studies did not clarify whether exercises focused on developing basic physical abilities such as strength, endurance, speed and flexibility might have positive effects on wheelchair users, other training methods or systems need to be brought into play. According to on this premise, there is a controversy in which it is suggested that "the progress of maximal strength does not correspond to an equal increase in strength endurance or speed strength, since a successive reduction in these specific abilities immediately becomes apparent if the training is not modified" (Mirella, 2001, p. 54), which indicates whether training focused on developing strength endurance may influence relative strength. Similarly, the relationship between the results of tests in which one muscle group is primarily involved and those obtained by evaluating the muscle activity of the opposite muscle group is unknown. Furthermore, in the general population, the relationship between the development of strength and the subjective perception of factors other than physical self-concept is unknown, bearing in mind that other feelings which influence the individual and collective development of each person must also be taken into account. Moreover, neither are the perceptions of people with paraplegia of their independence and its possible relationship with basic physical abilities known.

The objective of this study was to examine whether there was a relationship between relative strength development and self-perception of independence in adults with paraplegia by measuring relative strength using the shoulder muscle group, exploring whether this was related to self-perception of independence in the activities of daily living of adults with paraplegia. Furthermore, the degree of such an influence was examined and the mean percentage of variation in both relative strength and self-perception of independence after a six-week intervention programme was obtained. There are also the particularities of focusing on the development of a type of strength opposite to relative strength, namely strength endurance (Bompa, 2003; Jimenez et al., 2007). Therefore, the study was also designed to observe the development of relative strength in the shoulder muscle group, which is antagonistic to the dorsal muscle group (Willmore & Costill, 2004), the main group in the activities of daily living of people with paraplegia (Gottlob, 2008).

Figure 1
Study design.



Methodology

A quasi-experimental longitudinal follow-up study was performed with a pre-post facto design based on a six-week intervention. The physical activity programme involved working on the strength endurance of the upper body muscles, specifically the pectoral, dorsal, abdominal, biceps and triceps. The exercises were based on calisthenics and free weights mainly with dumbbells, following the structure of four series of 20 repetitions each with 40 seconds' rest between each series, as in the study carried out by Willmore and Costill (2004).

Figure 1 shows the design of the study derived from the objective.

Participants

The sample was comprised of eight people with physical-motor disabilities, five men and three women, with an age range between 22 and 39 years (29.5 ± 5.17) and residing in the Community of Madrid. The inclusion criteria specified: a) having a spinal cord injury; b) having a spinal cord injury below D5; c) having an ASIA C, D or E scale (American Spinal Injury Association, ASIA); d) not performing any kind of physical or sports activity in their daily lives prior to the study; and e) not undergoing continuous weight changes prior to the study. The exclusion criteria were as follows: not having physical-motor disability combined with another form of disability and not performing intense physical activity in their jobs.

All the participants were informed about all the activities to be carried out in the study before it and signed the informed consent form to indicate their voluntary participation and commitment. The study protocol was approved by the Autonomous University of Madrid Ethics Committee and also complied with the guidelines of the Declaration of Helsinki (2000).

Instruments

Barthel Index questionnaire

The Barthel Index questionnaire (Granger et al., 1979) was used to evaluate independence in the activities of daily living of people with disabilities. The questionnaire consisted of 10 items assessed using a Likert scale, each one with a score of 0 to 4. It was tailored to the needs of the study, as it is a questionnaire which can be adapted, and both the number of items and the score can be chosen, according to Barrero, García-Arrioja and Ojeda (2005).

The items specified in the questionnaire were: Personal hygiene, Getting in and out of the shower, Eating, Using the toilet, Going up and down stairs, Getting dressed, Moving from wheelchair to bed and returning, Moving without wheelchair, Moving with wheelchair, Getting in and out of wheelchair. The scores meant: unable to do so (0); tries to do so but is insecure (1); some assistance needed (2); minimal assistance needed (3); and totally independent (4). The range of scores was therefore from 0 to 40 points. The higher the score, the more independent the participants felt. Conversely, the lower the score, the less independent they felt.

Relative strength

The NSCA defines relative strength as the ability to lift and accelerate body movement, giving the result of maximal strength (S_{max} = 1 RM) divided by body weight (BW).

Procedure

Firstly, the participants were informed about the process and then completed the Barthel Index questionnaire (BIQ) based on the points explained.

Body weight was then measured; the participants were weighed using a scale with a margin of error of one gram per kilogram of weight measured, and the data were also recorded to the first decimal place (kilos and hectograms). The measurement taken made in the same time interval for each participant, who wore the same clothing for all measurements, consisting of underwear, socks, trousers and T-shirt. In order to ensure that measurements were taken in the same conditions, all the participants were weighed at a set time after their last food intake, as this is an influential factor (Casanueva et al., 2008). This datum was gathered on two consecutive occasions and was considered valid when the scales showed the same weight both times.

Subsequently, the front shoulder press exercise was performed to measure maximal strength using a 4.5-kilo bar and discs of varying weight. In the exercise, participants performed 10 repetitions with the maximum weight they felt they could manage, calculating maximal strength at 70% of this amount (Cronin & Hansen, 2005). The 10-repetition procedure was used instead of a maximum repetition in order to reduce the risk of injury to participants, since higher loads increased such risk (Willmore & Costill, 2004).

Exercise performance consisted of vertical movement of the arms from a position in which they were parallel to the ground (90-degree elbow flexion) to maximum extension above the head (total elbow extension). The participants sat on a chair used by all of them, to which their trunk was securely fixed by means of Velcro straps in order to avoid compensation by other muscles not required in the exercise (Monroy, 2011). A stopwatch was also employed to set the exact same rest time between possible repetitions of the exercise by some participants, as they sometimes performed the exercise and at the end of it felt they could lift more weight. A three-minute rest time was set, which was appropriate for achieving maximum efficacy in the maximal strength method (Bompa, 2003). Finally, these data were used to record the relative strength index, the result of dividing the kilos of maximal weight lifted by the kilos of body weight of each one of the participants, which was noted on a datasheet.

After the measurements, the participants began the physical activity programme, which consisted of exercises designed to develop strength, endurance, speed and flexibility (Mirella, 2006).

The intervention was organised into nine one-hour sessions held three times a week. After three weeks, the variables were measured. On the following day, the second part of the programme was resumed, consisting of the remaining nine sessions. Finally, after six weeks the variables were measured for the third and last time. Three measurements were chosen to verify whether the changes occurring between the first and third measurements followed a consistent order during the middle stage of the experimental process (Arnau & Bono, 2008).

Data analysis

The data were recorded using Microsoft Excel 2010 Professional Plus, and the statistical analysis was performed using SPSS version 22. The data met a normal distribution according to the Shapiro-Wilk test (Pedrosa et al., 2015). As the study was longitudinal, the general linear model (Arnau & Bono, 2008) was used to analyse repeated measurements with a significance level of $p < .05$ to check for significant differences in changes in relative strength and BIQ score during the process, and the Bonferroni interval adjustment was added to compare the three pre-, intermediate and post- study measures in pairs (Gil, 2015). In addition, the Pearson correlation coefficient was applied to extract the type of relationship in the changes produced between both variables (Pedrosa et al., 2015). In the interpretation of this type of relationship, values of < .20 were considered as very low; between .20 and .39 as low; between .40 and .59 as moderate; between .60 and .79 as high; and between .80 and 1 as very high (Morrow et al., 2005). Similarly, the coefficient of determination was extracted to obtain the percentage of reliability that the potential changes in relative strength would impact the change in the Barthel Index questionnaire score (Pedrosa et al., 2015). Meanwhile, the percentages of each participant were calculated and then added up and the total was divided by the study sample to establish the mean variation percentages.

Results

As can be seen in Table 1, the study participants presented changes in both their relative strength and BIQ. In relative strength, positive changes were observed, except in participants 4 and 6. Furthermore, positive changes in BIQ were seen after the intervention.

Table 1
Evolution of relative strength and BIQ between the first and last measurements.

Participant	Measurement	RS	% change	BIQ	% change
1	1ª	0.34	32.35%	23	26.09%
	3ª	0.45		29	
2	1ª	0.32	43.75%	23	21.74%
	3ª	0.46		28	
3	1ª	0.28	25.00%	22	9.09%
	3ª	0.35		24	
4	1ª	0.31	- 3.23%	27	0.00%
	3ª	0.30		27	
5	1ª	0.36	41.67%	16	43.75%
	3ª	0.51		23	
6	1ª	0.45	- 4.44%	34	0.00%
	3ª	0.43		34	
7	1ª	0.35	34.29%	31	22.58%
	3ª	0.47		38	
8	1ª	0.23	34.78%	33	9.09%
	3ª	0.31		36	

Abbreviations: RS: relative strength; % change: change percentage; BIQ: Barthel Index questionnaire.

The operability of relative strength comprised an unlimited range, while in BIQ the response range was between 0 and 40. Finally, table 2 shows that there were significant changes in both study variables, with greater variation in relative strength than in BIQ scores.

The results indicated a direct correlation between relative strength and BIQ scores ($r = .933$), which was considered very high, showing that changes in relative strength in each one of the participants were related to BIQ scores across all three data measurements in the study. Thus, the coefficient of determination presented a high-influence value ($R^2 = .871$), which meant that there was an 87.1% probability that the variation in the BIQ score over the three measurements could be explained by the changes in relative strength.

Table 2
Descriptive values

	M (SD)	S-W	$p < .05$
Relative strength	0.08 (0.07)	0.21	.03
BIQ	3.75 (2.92)	0.22	.04

Abbreviations: M: mean; SD: standard deviation; S-W: Shapiro-Wilk normality test values; BIQ: Barthel Index questionnaire. The significance level is $p < .05$.

Discussion

This paper focused on the impact of relative strength on self-perception of independence in the activities of daily living of adults with paraplegia. It also explored the degree of relative strength, and additionally determined the mean percentage of variation in relative strength and self-perception of independence separately.

The most significant result of the study was the assertion that changes in relative strength are strongly associated with this population's self-perception of independence. Furthermore, the percentage increase in the group mean for relative strength represented a substantial improvement.

Unlike previous research (Serra, 2011), this paper showed variations in relation to relative strength. The results point to significant changes in relative strength after six weeks of intervention in people with paraplegia; however, there are studies in people with intellectual disability whose performance is lower after doing strength

tests (Cabeza Ruiz & Castro Lemus, 2017), whereby a certain degree of caution is required when generalising the findings. In this respect, the proposed intervention may bring about significant changes in adults with paraplegia who do not perform any other physical activity outside the programme or any other physical activity prior to it.

Taking previous studies as a reference, Jiménez et al. (2007) studied the implications of strength endurance for speed and fatigue, it being considered that the development of relative strength has proportional changes together with these two factors in the independence of adults with paraplegia. Strength endurance was worked on in the physical activity programme analysed and led to positive changes in relative strength. However, studies by other researchers found no impact at all. Mirella (2001) does not draw precise conclusions about the influence of relative strength on independence, which is why these results differ from previous studies.

It is important to stress that the literature concerning relative strength in people with physical disabilities is scant, which constitutes a challenge in conducting research in this group. While there are a number of studies in which strength measurements were taken in wheelchair users (Wilbanks & Bickel, 2016; Cabeza Ruiz & Castro Lemus, 2017), these studies did not address relative strength.

In terms of the characteristics of the physical activity programme, this paper is similar to that of Hicks et al. (2003), who observe no significant changes in the first stage of their programme, hence self-perception and external perception might be said to present discrepancies with regard to independence taking the intervention into account.

Similarly, Hicks et al. (2003) established a nine-month physical activity programme with two weekly sessions to observe the possible transference from strength development to independence. By contrast, in this study, changes were apparent after three weeks, bearing in mind that in both sets of research none of the participants had done any previous physical activity.

With regard to the recording of relative strength data, resources such as MuscleLab are recommended as a reliable tool for ascertaining maximal strength, since Padullés and López (2011) argue that it can identify and describe the events which occur in muscle contraction. This would make it possible to confirm, with the utmost confidence, that each participant used their muscle fibres involved in the effort at the maximum possible contraction.

There were two specific limitations with regard to body weight. The first was weight variation throughout the process. Although these weight changes were minor and the differences were not significant ($.231 > .05$), the participants' weight fluctuations ranged from a .6 kg gain to a 1.6 kg loss. The second limitation was in the intake times prior to weighing on the scale.

Adherence to the programme was 72.7%. This figure reflects the number of participants who completed the full physical activity programme, since three participants dropped out of the study for personal reasons; these withdrawals do not influence the results, because in these cases only the first data set had been collected. In this respect, it would be useful to explore this question in greater depth in a larger sample in future research designed to compare the different types of strength and ascertain which one would have the greatest impact on factors such as independence or self-perception of independence in people with paraplegia, as well as in studies focusing on self-perception in this population group.

Conclusion

After six weeks of intervention there were significant changes in terms of relative strength and self-perception of independence which improve the performance of activities of daily living. Using the BIQ and measuring relative strength are recommended as tools for supervising and monitoring a physical activity and strength programme in people with paraplegia for initiation and also to establish functional changes during the rehabilitation and recovery process. In this respect, it is important to underscore the need to set clear targets when implementing an intervention, include strength and endurance exercises in programmes targeting wheelchair users, and also to factor in self-perception of independence in order to enhance their quality of life.

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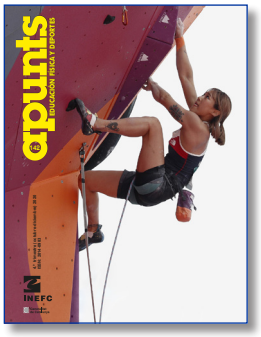

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Nutritional Intervention during Muscle Injury Considering its Pathophysiology: Review Article

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Abstract

Injury generates physical, emotional and financial costs and so strategies have been sought to shorten the recovery period as much as possible. One underused tool is nutrition. A review of the scientific literature is presented by means of a search in four databases (Pubmed/MEDLINE, Epistemonikos, Embase and Sportdiscus) on the pathophysiology of muscle injury and its nutritional modulation. Local changes mediated by cells and inflammatory mediators and secondary changes in body composition are described. Published nutritional interventions include increasing dietary protein and adjusting carbohydrates in line with the athlete's lower energy expenditure. There are no studies which have directly evaluated the use of supplements during injury, although there is mostly encouraging indirect evidence in sarcopenia and muscle recovery. Nutritional intervention during injury is essential to lessen the negative consequences of inactivity and should be indicated in an individualised way.

Keywords: injuries, nutrition, nutraceuticals, inflammation, immunomodulation.

Introduction

The occurrence of injury is something which is inherent in the life of an athlete even though efforts are made to prevent it. It involves physical costs and also emotional and financial ones both for the player and also for the institution in the case of team sports (Wall et al., 2014). It is known that half of all sports injuries can be considered serious with an average of more than three weeks of inactivity without training or competing (Tipton, 2015). Any prolonged injury brings with it periods of rest resulting in loss of muscle mass, strength and function (Pierre et al., 2016) so any intervention to decrease the period of immobility will be significant. Furthermore, the return to competition may be further delayed by muscle atrophy and increased abdominal fat which may take several weeks to resolve. This accumulation of "unwanted" fat tissue is aggravated by a reduction in the local metabolic rate of the damaged tissue and by a decrease in the muscle's sensitivity to insulin (Abadi et al., 2009; Pierre et al., 2016).

At present there are a number of treatments to foster and shorten recovery periods including cryotherapy, massage therapy, muscle stimulation and acupuncture (Dupuy et al., 2018). New treatments to shorten recovery times have also been investigated, such as platelet-rich plasma, monoclonal antibodies which inactivate inflammatory cytokines and local injection of growth factors among other invasive techniques. Many of these are expensive and present potential complications and adverse effects (Bachl et al., 2009; Mehrabani et al., 2019; Stöllberger & Finsterer, 2019).

One aspect that has been little studied, and at times underestimated, is the nutritional factor. Proper nutrition during the period of injury can help prevent the build-up of abdominal fat and might also optimise the tissue regeneration process and lessen muscle atrophy. It has been known for several years that nutrition can activate or inactivate the expression of our genome. A good example is leucine, an essential amino acid obtained from food which can activate the mTOR pathway by triggering protein synthesis, and hence it is used by many athletes to gain muscle mass (Duan et al., 2015; Li et al., 2011). If it were possible to plan a diet with the injured athlete featuring an appropriate intake of protein, foodstuffs with anti-inflammatory properties or ones which were able to modulate the immune response, the recovery period could be improved by achieving better quality tissue regeneration in the shortest possible time.

For centuries, many cultures have used foodstuffs with potential anti-inflammatory effects. However, the vast majority are not backed by sufficient scientific evidence to recommend them to athletes. Their usefulness, mechanism of action, appropriate dose and potential adverse effects are all unknown. It is therefore very important to have scientific proof of the highest possible quality in order to be able to indicate them with certainty as to their efficacy, thereby averting poor outcomes.

In recent years, studies have been conducted to test the immunomodulatory and anti-inflammatory effects of certain foodstuffs, most of which were performed in patients with sarcopenia or in muscle recovery after an eccentric exercise session (Beaudart et al., 2017; 2018; Chevalley et al., 2010; Colonetti et al., 2016; Cooke et al., 2010; Sousa et al., 2013). Their use in sports medicine, specifically for a sports injury, is an underdeveloped area yet with enormous potential as a future research strand bearing in mind how this intervention can reduce personal and financial costs. Consequently, the purpose of this review was to describe in detail the pathophysiology of muscle injury in each of its stages and then to present the most important aspects to be considered when conducting a nutritional intervention based on the scientific evidence available.

Methodology

This is a descriptive cross-sectional study of published articles by means of a narrative review. A search was conducted between February and July 2019 in four databases (Pubmed/MEDLINE, Epistemonikos, Embase and Sportdiscus) for scientific articles referring to the pathophysiology of muscle injury and its nutritional intervention during the recovery phase. Publications were included from the beginning of the indexation, giving priority to the search for systematic reviews and meta-analyses in the previous three years consistent with the classification of the quality of the evidence currently available. Publications not in Spanish or English and any not available in electronic databases were excluded. Initially a keyword search was performed with the Mesh tool including injury, athletic injuries, sports injury, nutrition, muscle regeneration, creatine, protein, whey protein, beta-hydroxy-beta-methylbutyrate, HMB, curcumin, vitamin D, Fatty Acids, Omega-3, Montmorency tart cherry and tart cherry. A further search was carried out using Boolean operators such as: "nutrition" OR "sports nutrition" AND "inj*", "Athletic Inj*" OR "sports inj*" AND "Sports Nutritional Sciences", "Athletic Inj*" AND "nutrition", "muscle Inj*" AND "nutrition", "protein" AND "athletic Inj*" OR "sports inj*", "creatine" AND "athletic Inj*" OR "sports inj*", "curcumin" AND "athletic Inj*" OR "sports inj*", "Fatty Acids, Omega-3" AND "athletic Inj*" OR "sports inj*", "vitamin D" AND "athletic Inj*" OR "sports inj*", "tart cherry" OR "montmorency tart cherry" AND "athletic Inj*" OR "sports inj*". A total of 21,498 articles were found. Duplicate studies and ones

that did not match the objectives of the study were eliminated, resulting in 202 publications which were finally considered in the review. In the review articles found, the primary studies taken into account by the authors were used. If no studies were found whose direct purpose was sports injury, the best available indirect evidence was sought such as nutritional intervention in the recovery of muscle inflammation, sarcopenia in older adults or in patients hospitalised after surgery. A summary of the search strategy is shown in Figure 1.

Results

No systematic reviews or randomised clinical trials concerning nutritional intervention during sports injury were found, making it impossible to conduct systematic reviews

Figure 1
Summary of methodology and search for information.

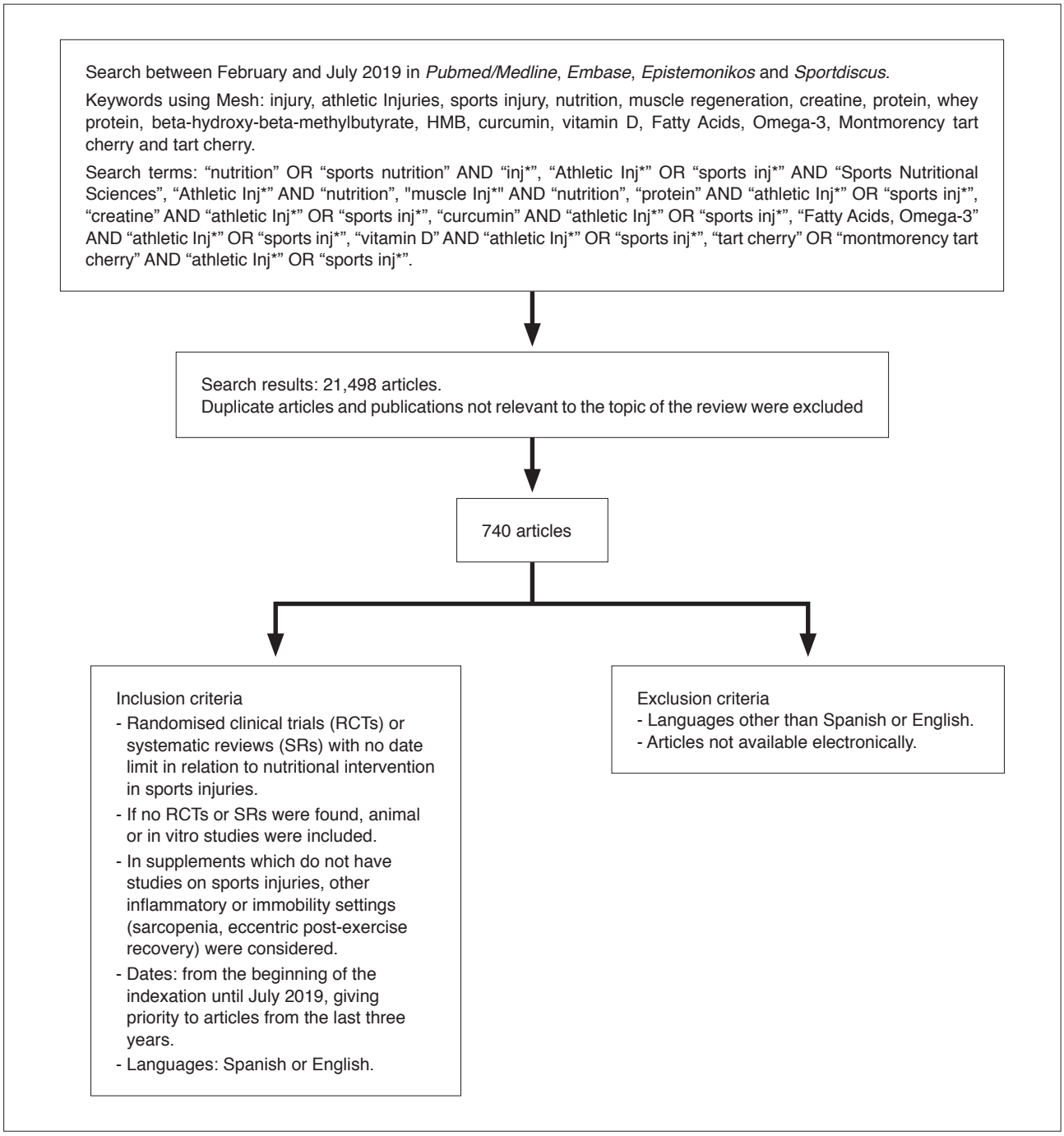
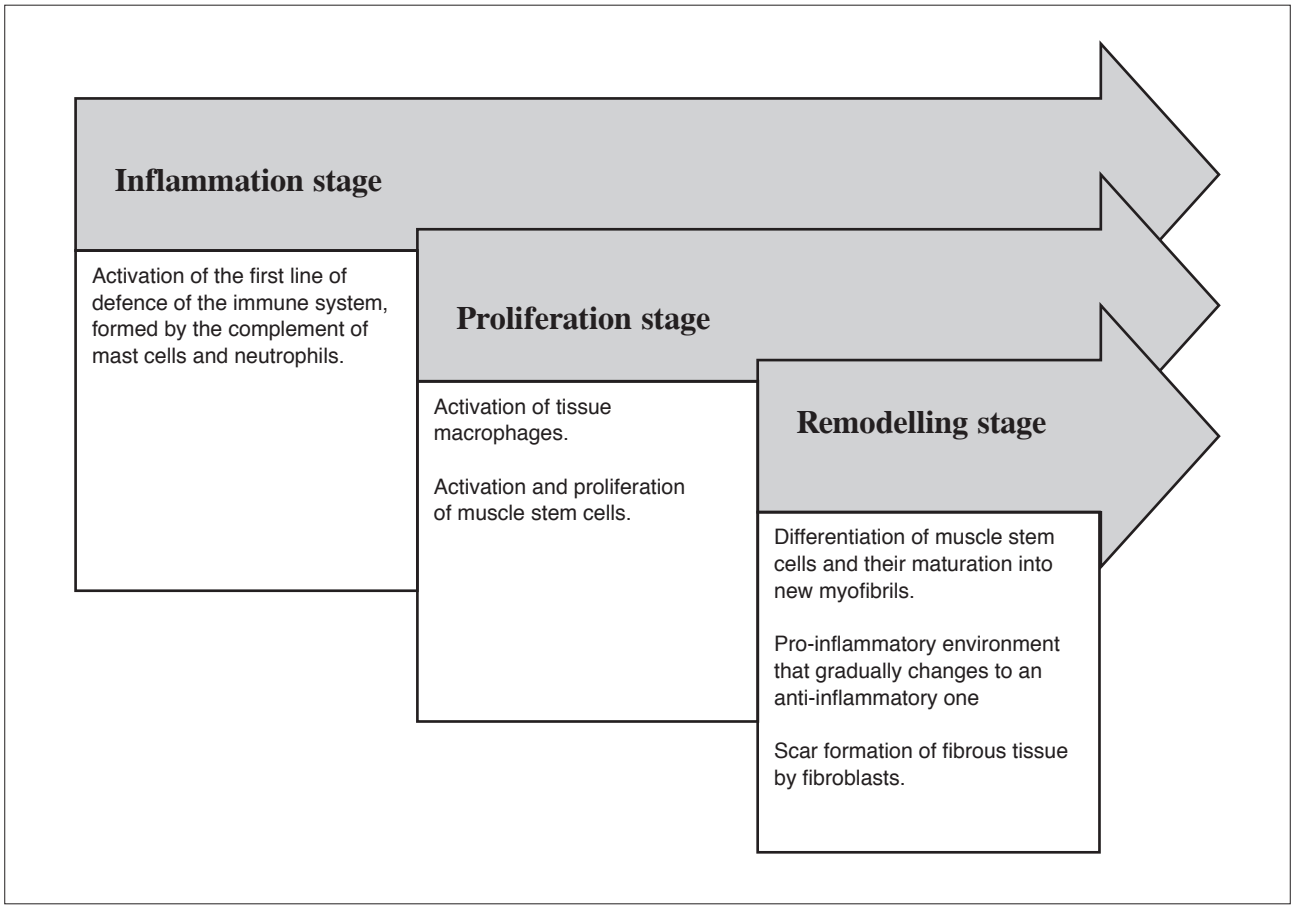


Figure 2
Diagram of the stages of muscle injury. They occur simultaneously and overlap with each other, which makes it difficult to delimit the beginning and end of each one.



concerning the topic. Only five narrative reviews of the topic were found (Close et al., 2019; Medina et al., 2014; Tipton, 2010; 2015; Wall et al., 2014) describing in general terms potential nutritional interventions during the recovery period. In addition, 152 articles related to supplements were found which might be useful bearing in mind their possible mechanisms of action.

Local changes at the site of the muscle injury

Pathophysiology of muscle injury

Although there are several classifications, one of the most used divides the changes in the muscle injury into three stages which overlap, making it difficult to delimit the beginning and end of them since they occur simultaneously. The *inflammation stage* starts from the moment of injury until the seventh day with the involvement of neutrophils, macrophages and lymphocytes. The *regeneration stage* is considered to be approximately from the second to the seventh day with the activation and proliferation of the muscle stem cells which migrate and fuse to replace damaged muscle fibres. Finally, there is the *remodelling stage* between the fifth day and the fourth week when muscle fibres and the extracellular matrix are formed and regenerated (Cheng et al., 2008). These stages are summarised in Figure 2.

1) Inflammation stage

Immediately after the injury, an inflammatory response begins which can last anywhere from a few hours to several days depending on the type and severity of the damage (Tipton, 2010). The first stage of the recovery process is called inflammation and is mediated by activation of the complement, the mast cells and neutrophils, which are part of the immune system's first line of defence.

It is characterised by the necrosis of the damaged fibres, which release their contents into the extracellular space including chemotactic factors which attract inflammatory cells.

Table 1
Summary of methodology and search for information.

	Systematic reviews/ meta-analysis	Randomised clinical trials	Narrative reviews	Total
Pathophysiology of the injury	2	18	25	45
Nutritional intervention in sports injuries	0	0	5	5
Injury supplements				
a) Whey protein	3	8	13	24
b) Creatine	3	5	3	11
c) Curcumin	9	9	7	25
d) HMB	6	14	10	30
e) Omega 3	0	11	7	28
f) Tart cherry extract	0	10	5	15
g) Vitamin D	2	11	6	19
Total of articles included				202

The complement system is the first sensor of muscle damage and is activated within seconds of injury. This activation allows neutrophils and macrophages to reach the site of damage (Frenette et al., 2000). In addition, the mast cells are also activated and their degranulation is one of the earliest responses of the innate immune system. Once activated, mast cells release inflammatory cytokines, such as tumour necrosis factor α (TNF-α), interleukin-1 (IL-1) and histamine, which in turn recruit more mast cells, neutrophils and other inflammatory cells (Yang et al., 2018). Finally, neutrophils are one of the most important inflammatory cells in the early stages after injury. Like mast cells, they are activated in skeletal muscle, releasing inflammatory cytokines such as TNF-α, IFN-γ and IL-1β. Their activation is very quick and they invade the damaged fibres within the first two hours of the injury. The number of neutrophils peaks between six and 24 hours after injury and declines rapidly by 72 to 96 hours (Arango et al., 2014). These neutrophils temporarily worsen the muscle damage and delay the next stage of cell regeneration by releasing IL-1 and IL-8 which induces the arrival of macrophages at the site of inflammation (Yang et al., 2018).

2) Second stage. Proliferation

It is characterised by the activation and proliferation of muscle stem cells associated with the appearance of macrophages and T cells. Muscle stem cells enable muscle cell regeneration. They are located within the basal lamina surrounding the myofibres, just between the muscle basement membrane and the basal lamina. They are present in all skeletal muscles and are associated with all types of muscle fibres, but not all of them have an equal distribution. For example, the percentage of muscle stem cells in adult soleus muscle (slow fibres) is two to three times larger than in the tibialis anterior muscle (fast fibres). Furthermore, their number decreases over the years which would explain why the regenerative capacity of skeletal muscle in response to damage decreases significantly with age (Järvinen et al., 2005).

Macrophages are produced in the bone marrow as monocytes, which are recruited by the action of neutrophils. They begin to be seen 24 hours after the injury, increasing two days later, and then decreasing rapidly until the fifth day (Tidball, 2005). Macrophages play a primary role in the regulation of muscle regeneration. They can be classified into two large groups: activated M1 macrophages, with an obviously inflammatory role, and M2 macrophages, also called "alternatively activated", which are anti-inflammatory (Mantovani et al., 2004). M1 macrophages are the dominant ones during inflammation, removing the cellular debris generated by the trauma as a result of the release of cytokines such as TNF-α, IL-6 and IL-1β. TNF-α plays an important role in muscle regeneration. Laboratory studies with mice without this cytokine or with blockage of its receptor showed severe alterations in muscle regeneration (Chen et al., 2005). TNF-α can

attract muscle stem cells to the site of injury and promote their proliferation by activating the nuclear transcription factor kappa β (NfKβ).

IL-6 is produced by multiple inflammatory cells, including macrophages and T-cells. It has been shown to stimulate myoblast migration, proliferation and differentiation. In animal models with overexpression of IL-6, activation of muscle stem cells was increased. In addition, IL-1β is mainly produced by macrophages, fostering the arrival of other macrophages and T cells and stimulating the production of IL-6 by muscle stem cells (Yang et al., 2018).

T cells are the largest cell population to be recruited in the second stage of inflammation. Both CD8+ and CD4+ cells are attracted to M1 macrophages, appearing at the site of injury on the third day and remaining until the tenth day (Cheng et al., 2008). Similar to macrophages, T cells synthesise a variety of growth factors and cytokines to modulate the inflammatory environment. Mice with T-cell deficiency show alteration in the regeneration process while adding them makes it possible to regain the regenerative process (Fu et al., 2015). Furthermore, the application of peptides secreted by human T cells accelerates the regeneration process, suggesting that these cytokines and growth factors secreted by T cells facilitate muscle regeneration (Yang et al., 2018).

3) Third stage. Remodelling

In this stage, muscle stem cells differentiate and mature into new myofibres. The pro-inflammatory environment gradually becomes an anti-inflammatory one, which is brought about by the change of macrophages from M1 (pro-inflammatory) to M2 (anti-inflammatory). M2 macrophages produce anti-inflammatory cytokines such as IL-4, IL-10 and IL-13. In addition, M2 macrophages are involved in the late stages of muscle regeneration. The absence of M2 macrophages leads to delayed muscle growth and inhibits muscle differentiation and regeneration.

Regulatory T cells are a type of T cell. Their number is low during the early stages of inflammation but increases sharply in later ones (Fu et al., 2015). These regulatory T cells secrete IL-10 and other cytokines to facilitate the conversion from M1 to M2 macrophages.

In lockstep, a scar of connective tissue is gradually formed at the site of the hematoma by the action of fibroblasts and which is designed to provide an anchor for the new myofibrils in formation. Fibroblasts are cells with a key role in tissue regeneration since they proliferate in close relationship with muscle stem cells. The absence of fibroblasts leads to early differentiation of the muscle stem cell, preventing the formation of myofibrils. Although fibroblasts are responsible for the formation of the fibrous scar, reciprocal stimulation with the muscle stem cells is very important to define whether a new myofibril will form or an unwanted collagen scar will develop.

A) Secondary changes during an injury

The period of inactivity associated with the inflammatory mediators during the injury has other consequences which if not addressed will further slow down the return to competition and the previously existing level of play.

A.1 Muscular atrophy

When an athlete has a major injury, in most cases there is an initial period of immobilisation or reduced physical activity called the "immobility or atrophy stage", which can range from a few days to several months. Inactivity can result in significant losses of muscle mass and strength, which in turn also alter the structure and function of the tendon. Significant losses of muscle mass have been described with only five days of immobilisation. However, changes in gene expression within the first 48 hours of rest have also been studied. These changes in muscle mass are due to an imbalance between protein synthesis and protein degradation. Studies with isotopic markers show that both protein degradation and synthesis decrease after 14 days of strict bed rest, but synthesis is affected to a greater extent thus generating this negative protein balance (Tipton, 2015).

A.2 Loss of muscle metabolic flexibility

Metabolic flexibility is defined as the ability of the body to respond or adapt to energy or metabolic demands in a given situation. It has been linked to the generation of insulin resistance, obesity and type 2 diabetes mellitus (Goodpaster & Sparks, 2017). Mitochondrial oxidative function and metabolic flexibility are affected during the first weeks of rest as mitochondrial protein transcription lessens, signalling pathways related to mitochondrial biogenesis decrease and there is a significant fall in mitochondrial enzyme activity. Some of these changes are already visible 48 hours after the start of inactivity. This mitochondrial dysfunction leads to lower glucose transport by GLUT4 generating resistance to the action of insulin (Tipton, 2015), which also later on impacts the build-up of total body fat.

A.3 Anabolic resistance

During this rest period and associated with the synthesis of inflammatory mediators which also takes place at this stage, "anabolic resistance" is generated in which the response of muscle protein synthesis with the amino acids available is reduced. It is suggested that this anabolic resistance might be produced by slowed down digestion and absorption of amino acids, an alteration in muscle microvascular perfusion which would alter the incorporation of amino acids by the muscle and a blockage in intracellular anabolic molecular signalling (Glover et al., 2008).

A.4 Bone, tendon and ligament alterations

Immobilisation affects not only the muscle cell but also all the supporting tissue which is directly and indirectly involved with the muscle. During immobilisation, the synthesis of collagen by the tendon decreases, altering its mechanical properties which are critical to its functioning (Tipton, 2010). However, the changes which take place in the connective tissue surrounding the injury still need to be studied.

A.5 Deregulation of energy needs

It is obvious that energy requirements will be lower during the immobilisation stage as there is no training or competition. However, there are other changes in energy requirements which should also be borne in mind. The healing of the muscle injury itself will induce higher local energy demand due to the need to synthesise new proteins for recovery. This additional energy expenditure may increase by 15% to 50% depending on the degree of inflammation and severity, size and duration of the injury (Tipton, 2015). Furthermore, if the injury is in the legs, there will be problems with walking and sticks or braces will often be needed which can double the energy requirements for walking (Tipton, 2015). Consequently, the new energy requirements of the injured athlete need to be calculated individually depending on the type of injury and their daily activity.

A.6 Psychological and emotional response

When an injury occurs, the athlete experiences not only physical changes but also emotional ones. The recovery period will be a difficult time of anxiety and depression with the uncertainty of not knowing exactly what the rehabilitation process will be like and the potential implications for their performance when they return to competition. Dietary alterations are common, which may range from an increase in consumption of high-calorie foods to excessive restriction, both of which have consequences for their body composition. An athlete with depressive symptoms will adhere less to the medical team's nutritional guidelines, so ideally it would be important to work with a sports psychologist to change the athlete's perception of this period.

B) Nutritional intervention during injury

The first nutritional intervention described in the literature during the immobilisation period is to avoid nutritional deficits in vitamins, minerals and macronutrients. The macronutrient which would most impact recovery from injury would be protein in the diet, since it would not only alter myofibrillary protein synthesis but also have a direct effect on muscle metabolism. There are no studies which have determined the amount of protein needed to prevent muscle atrophy specifically during the dormant period of an athlete's injury. Studies in men by Tipton et al. showed that providing high doses of protein (2.3 grams of protein per kilogram) decreased the loss of muscle mass in periods of negative energy balance compared to athletes who received 1 gram of protein per kilogram per day. This study was not conducted on injured athletes but rather during periods of weight loss (Tipton, 2015). It is known that providing 20 to 25 grams of protein in healthy active people in one dose maximises protein synthesis and anabolic resistance while the reduced physical activity suggests that a greater amount should be provided. This higher intake, which has not been described to date, should be distributed throughout the day. In the case of essential amino acids, there are also no papers on sports injuries.

The second intervention recommended in the literature is to adjust the athlete's energy requirements. It is evident that the injured athlete will burn fewer calories per day due to their inactivity than one who trains normally. However, this adjustment is not so simple since other factors have to be taken into account. Scarring and protein synthesis generate an increase in energy expenditure which can rise by up to 50% depending on the type and severity of the injury and is estimated at up to 500 kcal in a man with significant muscle mass (Tipton, 2015). Furthermore, secondary expenditure on walking needs to be considered; an athlete who has to remain at complete rest in bed will not be the same as one who needs sticks which calls for greater energy expenditure. In spite of the above analysis, most often the injured athlete worsens their body composition due to their physical inactivity, increasing their fat mass both in the abdomen and in the limbs. It should be noted that not only is it important to adjust total daily calories but also the proportion of each of the macronutrients by decreasing carbohydrates and proportionally increasing protein intake.

Finally, the third intervention is the use of dietary supplements including whey protein, creatine, HMB and anti-inflammatories such as curcumin and tart cherry extract among others. To date, there are no studies using these supplements in sports injuries, but there is indirect evidence of their likely usefulness. Whey protein and curcumin have been shown to decrease inflammatory markers such as TNF-α, IL-1α and IL-1β (Derosa et al., 2016; Patel, 2015), so they could be used as immunomodulators in the early stages of muscle injury. An in vitro study showed that tart cherry can reduce COX-2 activity by 38.3%, which is equivalent to the effect of anti-inflammatory drugs such as ibuprofen or naproxen (Bell et al., 2013). Likewise, vitamin D receptors (VDR)

have been found in in vitro studies on muscle stem cells which provide muscle regeneration after injury (Braga et al., 2017).

While there is indirect evidence for the use of dietary supplements to modulate muscle inflammation, the possible outcomes during an injury are unknown as the inflammatory process is acknowledged to be vital for proper tissue regeneration. For example, COX-2 through PGE2 plays a role in fibroblast proliferation and is a potent regulator of TGF-β1, which in turn is involved in collagen synthesis. Blocking TNF-α has also been shown to have negative effects on the recovery process, especially in its late stages (Sass et al., 2018; Tidball, 2005). Consequently, if it were possible to learn the right time to reduce inflammation without affecting the quality of the new tissue by using the appropriate supplements and/or foods, this process could be better modulated. An example would be to modify the activation of M1 macrophages towards an anti-inflammatory response mediated by M2 macrophages in chronic injuries with components present in the diet such as curcumin or tart cherry extract, which would make it possible to control the excessive inflammatory response which emerges in certain injuries.

Discussion

There are only a few published papers at present concerning nutritional interventions during the period of an injury. The vast majority of studies are conducted to promote muscle recovery or prevent osteopenia in older adults which means they are only indirectly applicable. More research on young athletes with sports injuries is needed to better apply the results.

Table 2
Evidence for major nutritional supplements.

Whey protein
• The milk protein-supplemented group showed greater bone callus in area and volume than the control group in tibia fracture in mice (Yoneme et al., 2015).
• In knee arthroplasty, the placebo group had large quadriceps muscle atrophy at -14.3±3.6% change after two weeks from surgery compared to -3.4±3.1% in the supplemented group. Positive effects were also evident at six weeks of follow-up (Dreyer et al., 2013).
• In older adults with sarcopenia, a systematic review concluded that providing protein plus strength exercises was significantly more effective in preventing age-related muscle loss than the group using only strength exercises without protein supplementation (Liao et al., 2017).
Creatine
• In athletes after two weeks of inactivity, the creatine-supplemented group showed greater changes in the muscle cross-sectional area of the fibre (10% higher) and in maximal strength (25% higher) during the rehabilitation phase (Hespel et al., 2001).
• In healthy people in the immobilisation phase, creatine was able to prevent the decrease of muscle GLUT4 during immobilisation, increasing its content by 9% during the rehabilitation period compared to a decrease of 20% in the control group (Eijnde et al., 2001).
Beta-hydroxy-methyl-butyrate (β-hmb)
• In a systematic review conducted in older adults for prevention of sarcopenia, increased muscle mass was obtained in the HMB group (0.352 kg; 95% CI: .11, .594) without showing significant changes in muscle strength (Wu et al., 2015).
• The use of β-hmb was more potent in reducing muscle catabolism (.38±.04) than leucine (.76±.04) and α-ketoisocaproate (.56±.04, $p<.05$) (Duan et al., 2018).
Curcumin
• Systematic review in patients with arthritis, decreased pain and inflammation-related symptoms, with similar results to ibuprofen and diclofenac sodium (Daily et al., 2016).
• The review showed the usefulness of curcumin in patients with osteoarthritis by inhibiting the gene expression of COX-2 but not COX-1, inhibiting the production of nitric oxide unlike the anti-inflammatory drugs (NSAIDs) studied. However, it was less effective than NSAIDs in blocking PGE_2 (Henrotin et al., 2013).

Table 2 *(Continuation)*
Evidence for major nutritional supplements.

Vitamin D
• Vitamin D receptor (VDR) is expressed in the muscle stem cells that provide muscle regeneration after injury (Braga et al., 2017). • Systematic review published in 2015 showed conflicting results among the studies included in recovery of strength after inducing muscle damage due to exercise (Minshull et al., 2015).
Omega 3
• Study with six weeks of supplementation with 3 grams per day did not alter strength, pain or inflammatory markers of muscle damage after 50 maximum repetitions of eccentric isokinetic knee extension exercises (Da Boit et al., 2017). • Study conducted on 22 paddlers, supplementation of 6 grams per day of fish oil (with 1.2 g DHA and 2.4 g EPA) for four weeks decreased the production of TNFα, IFN-γ and IL-1β while increasing IL-6 and IL-10 (Delfan et al., 2015). • Study conducted on young aerobic endurance athletes supplemented with 3.6 grams per day for six weeks did not alter levels of cytokines, creatine kinase or immune cell numbers (Da Boit et al., 2017).
Tart cherry extract
• In vitro study showed that tart cherry extract can reduce COX-2 activity by 38.3%, which is equivalent to the effect of anti-inflammatory drugs such as ibuprofen or naproxen (Bell et al., 2013). • A study of 16 semi-professional soccer players using 30 ml of tart cherry extract twice daily showed that IL-6 levels decreased significantly compared to the control group after intense intermittent exercise (Bell, Stevenson et al., 2016). • In half-marathon runners, inflammatory markers were 47% lower in the tart cherry extract group compared to placebo ($p = .053$) (Levers et al., 2016).

A key stage in recovery from an injury is the inflammatory stage in which multiple inflammatory mediators, immune system cells and components of the extracellular matrix interact to initiate tissue repair. This stage could be modulated with anti-inflammatory foods to shorten the recovery period and thus reduce costs. However, it is known that the inflammatory process is vital for proper tissue regeneration. For example, blocking TNF-α has also been shown to have negative effects on the recovery process, especially in its later stages (Sass et al., 2018; Tidball, 2005). Consequently, if it were possible to identify the right time to reduce inflammation without affecting the quality of the new tissue by using the appropriate supplements and/or foods, this process could be better modulated. An example would be to modify the activation of M1 macrophages towards an anti-inflammatory response mediated by M2 macrophages in chronic injuries with components present in the diet such as curcumin or tart cherry extract, in which case the excessive inflammatory response which takes place in certain injuries might be controlled (Table 3).

A very important point, and one which many athletes overlook, is that in order to get back to competition in the shortest time and at the highest possible level, not only does inflammation have to be modulated but also muscular atrophy and the accumulation of adipose tissue during the recovery period should be prevented as far as possible. The less atrophy and less increase in body fat there is, the faster recovery to the pre-injury level will be. It may take several weeks or even months to lose an excessive amount of fat and strengthen the muscles. This additional time is added after the athlete receives medical clearance to resume training and match play following a prolonged injury. To achieve these objectives, it is essential to adjust the energy requirements of the athlete by reducing their intake of carbohydrates and increasing protein in the diet to promote recovery. This adjustment needs to be individualised and tailored to each athlete. Severe calorie restriction may reduce protein synthesis by 20% to 30% (Tipton, 2015) which alters tissue regeneration and will exacerbate muscle atrophy. Regular monitoring is crucial to fine-tune the athlete's diet as they increase their physical activity.

There are no studies directly evaluating the use of supplements in sports injuries. As noted above, it is difficult to draw valid conclusions given the varying doses, types of patients and exercise protocols performed. It is also hard to assess the impact of an isolated dietary component bearing in mind how challenging it is to control intake of other foodstuffs which may influence outcomes. In addition, the variables measured are often subjective and not easy to quantify such as the level of pain or the

Table 3
Summary of the main inflammatory mediators present in recovery from a sports injury with their potential nutritional modulation based on current data.

Mediator or marker	Function	Nutritional intervention and its evidence
IL-1α	Stimulates the immediate immune response.	Systematic review shows a decrease with the use of curcumin as an adjuvant treatment with infliximab in Crohn's disease (Schneider et al., 2017). Whey protein reduces its level, acting as an immunomodulator (Patel, 2015).
IL-1β	Promotes the arrival of macrophages and B-lymphocytes. Promotes production of IL-6 by muscle cells.	Whey protein reduces its level, acting as an immunomodulator (Patel, 2015). Curcumin associated with resveratrol neutralised IL-1 -induced type II collagen inhibition (Henrotin et al., 2013). Omega-3 decreases its levels in paddlers engaged in intense exercise (Delfan et al., 2015). Curcumin decreases its levels in in vitro studies (Karimian et al., 2017).
IL-2	Promotes the proliferation of T-lymphocytes and memory cells.	Omega 3 increases its levels in paddlers engaged in intense exercise (Delfan et al., 2015). Whey protein increases its levels (Patel, 2015).
IL-4	Secreted by Th2 T helper cells with anti-inflammatory effect that suppresses the Th1 response.	Whey protein increases its levels (Patel, 2015).
IL-6	Pro-inflammatory cytokine produced by macrophages, monocytes and muscle cells among others.	Meta-analysis shows that curcumin significantly decreases its levels (Derosa et al., 2016). Curcumin decreases its levels in in vitro studies (Henrotin et al., 2013). Tart cherry extract decreased its level after intermittent intense exercise (Bell et al., 2016). Omega 3 inhibits its synthesis by the endothelial cell (Capó et al., 2016).
IL-7	Anti-inflammatory effect. Participates in the maturation of T and B lymphocytes.	Whey protein increases its levels (Patel, 2015).
IL-8	Produced by monocytes, neutrophils, fibroblasts and epithelial cells. Factor that attracts lymphocytes and neutrophils.	Whey protein increases its levels (Patel, 2015). Curcumin decreases its levels in in vitro studies (Henrotin et al., 2013). Omega 3 inhibits its synthesis by the endothelial cell (Capó et al., 2016).
IL-10	Anti-inflammatory cytokine. Inhibits pro-inflammatory cytokines of T-lymphocytes and macrophages. Fosters the shift from M1 to M2 macrophages.	Omega 3 increases its levels in paddlers engaged in intense exercise (Delfan et al., 2015).
TNF-α	Induces vasodilation, increased vascular permeability and infiltration of lymphocytes, neutrophils and monocytes.	Systematic review shows its reduction using curcumin (Sahebkar et al., 2016). Omega 3 decreases its synthesis after eccentric exercise (Da Boit et al., 2017; Delfan et al., 2015). Whey protein reduces its level, acting as an immunomodulator (Patel, 2015).
Prostaglandin E_2 (PGE_2)	Powerful vasodilator.	Curcumin decreases its levels in in vitro studies (Henrotin et al., 2013).

Table 3 *(Continuation)*
Summary of the main inflammatory mediators present in recovery from a sports injury with their potential nutritional modulation based on current data.

Mediator or marker	Function	Nutritional intervention and its evidence
Leukotrienes	Pro-inflammatory mediator derived from arachidonic acid.	Omega 3 decreases their levels by competing with arachidonic acid (AA) (Capó et al., 2016).
Cyclooxygenase 2 (COX-2)	Enzyme that allows the synthesis of prostaglandins from arachidonic acid.	Tart cherry extract inhibits it by 38.3%, equivalent to the effect of ibuprofen or naproxen (Bell et al., 2013). Curcumin decreases its levels in in vitro studies (Henrotin et al., 2013).
Total creatine kinase (CK)	Muscle damage marker.	Omega 3 decreases its synthesis after eccentric exercise (Da Boit et al., 2017).
C-reactive protein (CRP)	Inflammatory response marker.	Meta-analysis shows its decrease with the use of curcumin (Sahebkar, 2013).

degree of injury healing. The above data call for careful analysis of the results of the available studies without drawing definitive conclusions and trying to apply them with criteria specific to each case until new scientific evidence for enhanced applicability emerges.

It is important to underline that the best nutritional intervention is to give priority to an appropriate diet by encouraging consumption of fruits and vegetables. If there is a need to add to daily protein intake, this can be done by increasing its consumption via food. In situations where it is difficult to provide large quantities through diet, as is the case with curcumin, supplements can be used to obtain suitable plasma levels more easily and conveniently.

Further studies will be needed in the coming years to investigate the relationship of food with immune and systemic inflammation processes. In the nutritional field, new research avenues should be opened on sports injuries to determine which foods or supplements stimulate the muscle stem cells to regenerate the damage, modulate the inflammatory response by fostering the anti-inflammatory activity of M2 macrophages, prevent the formation of a fibrous scar and avert muscle atrophy due to immobility as much as possible. Apart from their usefulness, the appropriate doses, the best time for their administration and their possible adverse effects also need to be known.

Conclusions

Considering both the pathophysiology and the multiple local and secondary changes after a sports injury, personalised nutritional intervention is called for in an athlete with a long recovery injury based on the recovery stage they have reached. Macronutrients should be tailored to the new energy requirements of a recovering athlete through a personalised diet. This would make it possible to control the inflammatory process, enhance the quality of muscle regeneration, shorten recovery times and minimise muscle atrophy and the accumulation of abdominal fat, thus adding to the work done by physiotherapists and rehabilitation therapists. To date, there is not enough scientific evidence on the use of food and supplements in sports injuries. More research designed specifically for these patients is needed to specify the foodstuffs and supplements which are beneficial, the right doses, the right time and the duration of treatment.

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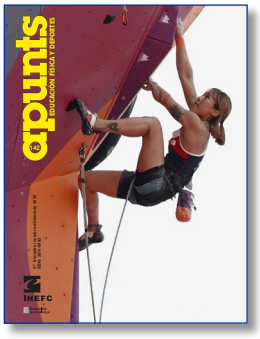

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Athlete's motivation and the quality of his relationship with the coach

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Abstract

This cross-sectional study investigated the influence of the perception of the quality of the coach-athlete relationship (CAR) on the motivation among young students-athletes in the state of Pernambuco, Brazil. Participants were 301 students-athletes who participated of the School Games of Pernambuco 2017. The instruments used were the Coach-athlete Relationship Questionnaire (CART-Q) and the Sport Motivation Scale-II (SMS-II). Data analysis was conducted through Kolmogorov-Smirnov and Mann-Whitney tests, Spearman Correlation and Structural Equation Modeling (SEM) ($p<.05$). The results showed that the students-athletes who perceive themselves with high quality of CAR had higher scores at identified, integrated and intrinsic regulations, while the athletes with moderate CAR had higher score at amotivation and external regulation. SEM revealed that both controlled and autonomous motivation were explained in 17 % and 21 %, respectively, by CAR, which had positive effect ($\beta = .45$ and $\beta = .41$) on both motivations. It is concluded that a positive relationship with the coach based on admiration, respect, trust and affiliation seems to be a fostering factor for the motivation in the school sports context.

Keyword: Self-determination; interpersonal relations; Sport; Psychology of Sport.

Introduction

Michael Phelps, the greatest Olympic medalist of all time, directly credits all his success and motivation for sports to his great relationship with Bob Bowman, the coach who accompanied him since he was 11 years old. Recent studies show that athlete's well-being, performance and motivation are influenced by the quality of the coach-athlete relationship (CAR) (Appleton et al., 2016; Davis, Appleby et al., 2018; Nascimento Júnior et al., 2018; Vieira et al., 2018).

CAR comprises a mutual interaction and causal interdependence between the thoughts, feelings and behaviors of coaches and athletes (Jowett & Shanmugam, 2016). Thoughts are related to commitment and intention to maintain the relationship over time; feelings refer to the perception of closeness (respect, trust, taste); and behaviors refer to complementarity, responsiveness and cooperation between coach and athlete (Jowett & Poczwardowski, 2007; Jowett & Shanmugam, 2016). CAR plays an important role in the physical, motor and psychosocial development of young athletes (Jowett & Shanmugam, 2016; Yang & Jowett, 2012). It happens because coaches are responsible for the delegation of tasks to be performed by the teams, so his actions may interfere with the current and future behavior of the athletes (Cheuczuk et al., 2016).

In that context, CAR has been pointed out as one of the major factors for the development of sports career in athletes (Davis et al., 2018; Nascimento Júnior et al., 2018; Vieira et al., 2018) and, as a consequence, a differential to the sporting success for young athletes (Cheuczuk et al., 2016). Thus, it is important that athletes and their social peers (family, coach and other people involved in sport) develop self-knowledge, since this attribute is essential for the identification of the factors that motivate these young athletes to practice and what are their goals from this instant (Carvalho, Verardi, Maffei, & Monesso, 2019).

Motivation has a great influence in situations of competition, being an obstacle or a stimulus to the athletes' performance (Pineda-Espejel et al., 2015). One of the most used theories to understand the process of commitment and adherence to sports practice at the different levels of competition (Almagro & Paramio-Pérez, 2017) is the Self-Determination Theory (SDT). SDT is a broad framework that explains the different motivational aspects by mini-theories. One of these mini-theories id the Basic Psychological Needs Theory, which postulates that self-determined motivation is influenced by three basic needs: autonomy, competence and relatedness, which seem to be essential for the social development and personal well-being (Deci & Ryan, 1985; Deci & Ryan, 2012).

SDT describes motivation through various regulatory styles (external, introject, identified, integrated and internal), which are presented in a *continuum* that represents the motivation from the least self-determined form (controlled motivation) to the most self-determined (autonomous motivation), based on various motivational forces underlying a person's behavior (Rigby & Ryan, 2018). Controlled motivation encompasses external or internal pressures (external and introjected regulations) and, largely, does not relate to personal needs and interests. Autonomous motivation is energized directly by the needs, values and interest of the individuals (identified, integrated and intrinsic regulations), resulting in volitive and high-quality motivation. Thus, individuals are committed to performing certain tasks well and, from this investment and effort, obtain greater satisfaction, vitality and well-being (Deci & Ryan, 1985; Deci & Ryan, 2012; Rigby & Ryan, 2018).

Faced with this scenario, recent studies indicate that autonomous motivation is associated with positive behaviors in sport (engagement and continuity in sport) (Carvalho et al., 2019; Vieira et al., 2018), while controlled motivation can lead to inadequate behaviors (stress, exhaustion, and abandonment of modality) (Carvalho et al., 2019). Cognitive Evaluation Theory states that social environment influences on people's behavior in sport (Deci & Ryan, 1985; Rigby & Ryan, 2018). In this perspective, CAR is a factor that can lead young athletes to the development of an autonomous or controlled motivation (Cheuczuk et al., 2016). Vieira et al. (2018) and García-Calvo et al.(2014) investigated the association between motivation and CAR among professional athlete players, however, no studies have been found to address such associations among young students-athletes, which is the gap this study aims to explore.

In addition, several authors suggest that future researches must assess the impact of the quality of the CAR on the different psychological variables among athletes of different competitive levels (Appleton et al., 2016; Davis et al., 2018; Nascimento Júnior et al., 2018; Vieira et al., 2018). Therefore, this research aimed to investigate the influence of the perception of the CAR on the motivation among students-athletes from the state of Pernambuco, Brazil.

Methods

Participants

This transversal study had as population students/athletes practicing collective sports, between 15 and 17 years of age of the School Games of Pernambuco 2017. It covers students-athletes from all over the state, being contested in the collective sports of basketball, futsal, handball, football and volleyball. The minimum number of participants was calculated from the sample formula for finite populations,

adopting a 95 % confidence level, an estimation error of 5 % and an expected ratio of 50 % (Richardson et al., 2012). Considering the estimated population of 2500 athletes for the competition, the minimum number of participants was 333 students-athletes, considering the possible sample losses. The inclusion criterion for the study was to have participated in some regional/state level competition during the 2015/2016 seasons.

In this way, 335 students/athletes of team sports were selected to the study; however, 34 athletes were excluded from the study due to problems in completing the questionnaires. Thus, participants were 301 male (136) and female (165) athletes with a mean age of 16.02 ± .83 years. Students/athletes participated in the following sports: Futsal ($n = 124$), volleyball ($n = 133$), handball ($N = 24$) and basketball ($N = 20$). Only the athletes who signed the consent term or had the term signed by the coaches (responsible for the athletes in the event) were selected to the research.

Instruments

Coach-Athlete Relationship Questionnaire (CART-Q) was used to measure athletes' perception of the quality of the CAR (Jowett & Ntoumanis, 2004), which was validated for the Brazilian context by Vieira et al. (2015). Four items assess about closeness (e.g., "I like my coach"), three items assessing commitment (e.g., "I am committed to my coach") and four items assessing complementarity (e.g., "When I am coached by my coach, I am ready to do my best"). All CART-Q items were measured on a 7-points likert scale ranging from 1 ("Strongly Disagree") to 7 ("Strongly Agree"). The Cronbach's alpha of the instrument dimensions ranged from $\alpha = .83$ to $\alpha = .95$.

Sport Motivation Scale-II (SMS-II) was used to assess athletes' motivation for the sport. SMS-II was developed by Pelletier et al. (2013) and validated for the Brazilian context by Nascimento Junior et al. (2014). It consists of 18 items distributed into six regulations (intrinsic, integrated, identified, introject, external and amotivation). Items are responded on a 7-points likert scale ranging from 1 (Does not correspond at all) to 7 (Correspond completely). The reliability of the scale was $\alpha = .74$. According to the categories proposed in the SDT *continuum* (Deci and Ryan, 2012), identified, integrated and intrinsic regulations are the components closer to autonomous motivation, while introject and external regulations are the components closer to controlled motivation. It is noteworthy that amotivation was not used for the main analysis, since it is a component that represents the total lack of motivation and the objective of the research was to investigate the associations between the motivation (autonomous and controlled) and the CAR.

Procedures

This study is integrated into the institutional project approved by the Ethic Committee of the Federal University of "Vale do São Francisco" (opinion 1.648.086). Initially, contact was made with Secretary of Sports of the State of Pernambuco to request permission to collect School Games from Pernambuco 2017. Data collection took place in the hotels where the teams were housed, as well as in the place where the competition took place, lasting approximately 30 minutes. The order of the questionnaires was randomized among the participants and the researchers performed the application individually.

Data analysis

Preliminary analysis. The preliminary analysis for the correlation and comparison analysis and was carried out by Kolmogorov-Smirnov normality test. Since data was non-normal, correlation of Spearman (non-parametric) was used to verify the relationship between variables. Such analyses were conducted in the SPSS v.22.0. For comparison of the regulations of motivation according to the quality of the CAR, the total score of CAR was obtained and, then, the athletes were divided into two groups (high and moderate quality the coach-athlete relationship) in accordance with the "median Split" (up to 6.58 = moderate; and above 6.58 = high). The level of significance adopted was $p < .05$.

Structural Equation Modelling (SEM). The main analysis involved SEM, using the software AMOS 22.0, which performs Covariance-based SEM. If the objective of the research is to test the theory, that is, its confirmation, the appropriate method is CB-SEM, which is the case of this study (Hair, Matthews, & Matthews, 2017). The hypothetical model verified the existence of three latent factors (CAR, autonomous motivation and controlled motivation) from the dimensions of the CARTQ and SMS-II. In this way, SEM tested the role of the quality of the CAR on athletes' motivation following the two-step model building approach recommend by Anderson & Gerbing (1988). The first step involves testing the measurement model by using a Confirmatory Factor Analysis (CFA), while in the second step the hypothesized structural model is tested.

Before the main analysis, we verified the data normality, missing values, and outliers for all study variables following the procedure outlined by Tabachnick & Fidell (2013). Examination of skewness and kurtosis for all variables indicated univariate normality based on the cut-off values of skewness < 3.0 and kurtosis < 10.0 (Kline, 2012). Analysis of Mardia's multivariate coefficient (> 5.0) indicated that the data distribution derived from multivariate normality, which justified the use of the Bollen-Stine bootstrap procedure to obtain a corrected Chi-squared value of the estimated coefficients for the Maximum Likelihood Estimator (Bollen & Long, 1993).

We used several fit indices to assess the model fit according to Hu & Bentler (1999) recommendations: chi square ($\chi 2$), Normalized Chi-Square ($\chi 2$/df), Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA), and its associated ninety-percent Confidence Interval (CI). CFI, GFI and TLI values close to or above .95, RMSEA values close to or below .08, and the lower end of 90 % CI of the RMSEA containing the value of .05 represent an excellent fit to the data for the hypothesized model (Hu & Bentler, 1999). Furthermore, we used these indices for both Step 1 and Step 2. Fit quality for the structural model (Step 2) was also assessed through its factor loadings (FL) and items individual reliability. The interpretation of paths was based on the following cutoff: small effect for paths up to .20; medium effect for paths between .21 and .49; and large effect for paths above .50 (Kline, 2012).

Results

There was a significant difference in all regulations of motivation ($p < .05$) according to quality of the CAR (Table 1), with the exception of introject regulation ($p = .055$). It is emphasized that athletes that perceived a CAR of high quality had higher scores at the identified, integrated and intrinsic regulations, while athletes with moderate perception of CAR had higher scores of amotivation and external regulation.

It was found significant ($p < .05$) and positive correlations of the regulations closer to the autonomous motivation (identified, integrated and intrinsic regulations) with all the dimensions of CAR (Table 2). On the other hand, amotivation showed negative correlations with all dimensions of CAR, while external regulation showed negative correlation with proximity ($r = -.14$).

The measurement model (Step 1) had acceptable fit [X^2 (17) = 21.57; $p = .202$; X^2/df = 1.27; CFI = .99; GFI = .98; TLI = .99; RMSEA = .03; p (RMSEA < .05) = .809]. The quality of the local adjustment and the internal reliability of the items were also confirmed, with all trajectories obtaining significant ($p < .05$) factorial loadings and higher than .50. Thus, the hypothetical model was analyzed (Step 2). The tested model (Figure 1) provided sufficiently adjusting indicators [X^2 (18) = 54.18; $p = .001$; X^2/df = 3.01; CFI = .96; GFI = .96; AGFI = .92; TLI = .94; RMSEA = .08; p (RMSEA < .05) = .018].

Table 1
Comparison of the regulations of motivation among young athletes according to quality of the CAR.

Variáveis	High CAR (n=148)	Moderate CAR (n=153)	p
	Md (Q1 - Q3)	Md (Q1 - Q3)	
Amotivation	2.33 (1.00 - 3.00)	3.00 (1.33 - 4.50)	.006*
External Regulation	3.00 (2.33 - 4.67)	3.33 (2.50 - 5.00)	.035*
Introjected. Regulation	5.67 (5.00 - 6.67)	5.67 (4.33 - 6.33)	.055
Identified Regulation	6.67 (6.00 - 7.00)	6.33 (5.33 - 6.67)	.001*
Integrated Regulation	6.33 (5.41 - 7.00)	5.67 (5.00 - 6.67)	.001*
Intrinsic Regulation	6.67 (6.00 - 7.00)	6.00 (5.33 - 6.67)	.001*

* Significant difference: p<.05 (Test "U" of Mann-Whitney).
Note: CAR = Coach-athlete relationship.

Table 2
Correlation between the quality of the CAR and regulations of motivation.

Variables	Motivational regulations						CAR		
	1	2	3	4	5	6	7	8	9
1.Amotivation		.45**	-.11	-.15**	-.23**	-.24**	-.16**	-.21**	-.12*
2.External Reg			.20**	.18**	.12*	.06	-.14*	-.09	-.07
3.Introjected. Reg.				.51**	.48**	.49**	.11*	.18**	.21**
4.Identified Reg.					.68**	.65**	.21**	.31**	.26**
5.Integrated Reg.						.63**	.19**	.29**	.23**
6.Intrinsic Reg.							.21**	.28**	.25**
7. Proximity								.66**	.71**
8. Commitment									.69**
9. Complementarity									

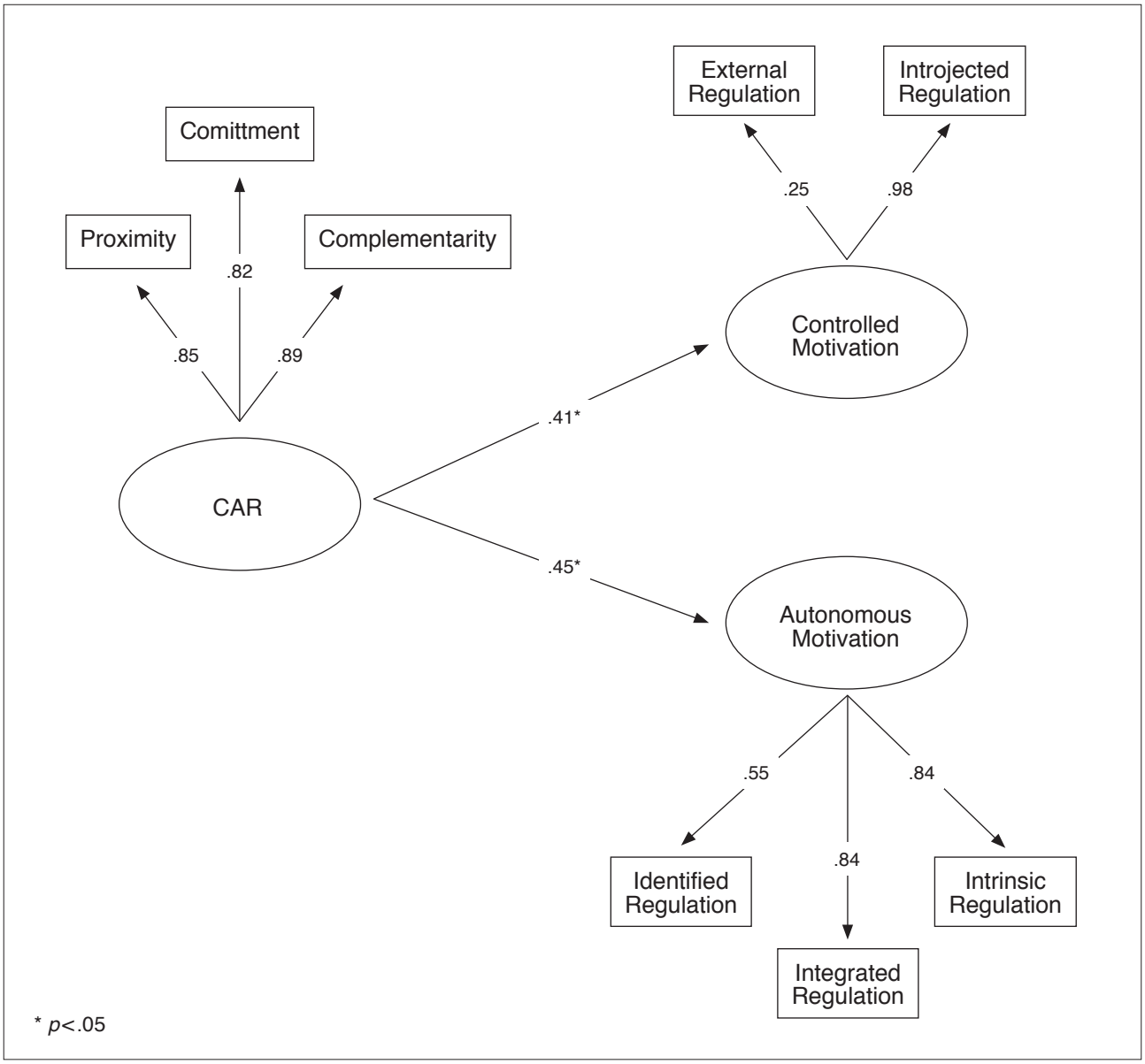
**The correlation is significant at the level .01. *The correlation is significant at level .05.
Note: CAR = Coach-athlete relationship.

The latent variables of controlled motivation and autonomous motivation were explained in 17% and 21%,respectively, by the quality of the CAR (Figure 1). In the direct association established between CAR and both autonomous and controlled motivation, the effects were positive (β = .45 and β = .41, respectively), indicating that each increase of 1 standard deviation in the unit of the CAR there is an increase of .45 and .41 standard deviation in the drive of both autonomous and controlled motivation. This finding shows that as much as young athletes perceive a positive relationship with the coach, mainly based on admiration, respect, trust and affiliation, they will be more motivated for sports practice, especially in an autonomous way.

Discussion

The purpose of this study was to investigate the influence of the perception of the quality of the CAR on motivation among young students-athletes of the state of Pernambuco, Brazil. The main results indicated associations between the quality of the CAR and both autonomous and controlled motivations (Figure 1). In addition, the students-athletes who showed higher perception of CAR quality were those who had the higher scores of autonomous motivation, while the athletes with moderate perception of CAR quality showed higher amotivation and controlled motivation (Table 1).

Figure 1
Structural model of the role of the CAR on the motivation of young athletes.



Note: CAR = Coach-athlete relationship.

The main result of the study concerns the linear association between the quality of the CAR and both autonomous and controlled motivation (Figure 1). This result may be due to autonomous motivation being responsible for participation and continuity in the sport, as well as the social connections originating from the sporting context (Balbinotti & Balbinotti, 2018; Carvalho et al., 2019; Bengoechea, 1997; Pérez-González et al., 2019). Thus, admiration, respect, trust and affiliation with the coach seem to act as protective factor against amotivation and low quality motivation among students-athletes for sports practice (Balaguer, Castillo, Ródenas, Fabra, & Duda, 2015; Jowett & Shanmugam, 2016; Vieira et al., 2018). These findings are in agreement with the elements of the Cognitive Evaluation Theory, which explains that social environment influences the type of behavior exercised by people (Prentice, Jayawickreme, & Fleeson, 2018). Corroborating our findings, Pérez-González et al. (2019) conducted a systematic review with youth students of physical education, verifying that higher levels of motivation, classroom engagement, and increased regular physical activity are consequence of the teacher's autonomy support. Moura et al. (2019) and Sánchez Oliva et al. (2012) observed that high quality CAR is essential to develop pleasure and satisfaction during sports practice in athletes. Moreover, social peers (e.g. parents, friends, idols) also work as a source of motivation for task accomplishment (autonomous motivation), as the inferences made by the coaches can reflect on the relationship of the team.

These findings are according to the SDT mini-theory of Relationships Motivation (Deci & Ryan, 2012), which points out that social environment exert influence on people's choices and continuity in the activity. Thus, social peers can stimulate the athletes to enhance individual and team skills. Vieira et al. (2018) also found that CAR is fundamental for behavior regulated by external factors not to negatively influence the perception of team cohesion in the context of professional football. On the other hand, Carvalho et al. (2019) have shown that low quality CAR can enhance youth football athletes' amotivation, leading to disengagement of the athletes in the sports.

Further, the correlations evidenced that regulations closer to autonomous motivation demonstrated higher associations with the dimensions of CAR (Table 2). These results indicate that when the thoughts and behaviors of students-athletes are mutually related to their coach/teachers, there is a greater tendency that students-athletes presents a behavior regulated by intrinsic factors in the face of sports practice (Carvalho et al., 2019; Pérez-González et al., 2019; Cheuczuk et al., 2016). These results receive support from SDT that it points out that the motivation of individuals is influenced by authority figures such as parents, coaches and teachers who conduct activities and impact on their development (Deci & Ryan, 2012). Thus, it should be noted that the positive experiences that these figures provide can focus on the psychological attitudes of young athletes as motivation and satisfaction.

Further, amotivation showed negative correlation with all dimensions of CAR (Table 2), indicating that athlete's lack of motivation and interest to perform a task is associated to a poor relationship with the coach (Table 2). According to with SDT, amotivation refers to the lack of motivation, both intrinsic and extrinsic, in which the individual has no (more) motive to accomplish the task and feels incompetent (Deci & Ryan, 2012). Although recent studies point out that amotivation for sports practice is also related to factors such as excessive training, injuries, bullying and low perception of competence (Myer et al., 2015), the social context is also considered a factor involved in the lack of motivation among adolescents (Vieira et al., 2013; Nascimento Junior et al., 2017). Nascimento Junior et al. (2017) found a strong relationship between amotivation and rejection and overprotection of the parents among futsal athletes, indicating that the negative influence of the social peers may increase the athlete's amotivation. Thus, the quality of the CAR is very important to keep the young athlete intrinsically motivated for sports practice.

Another important finding refers to the higher score in regulations closer to the autonomous motivation for athletes who perceive themselves with high CAR quality (Table 1) (Hampson & Jowett, 2014; Jowett & Shanmugam, 2016; Torres, 2014). These findings indicate that student-athletes who perceive higher proximity, commitment and complementarity with the coach are more self-determined to sports practice. Jowett & Shanmugam (2016) claim that diadic relationships allow the transformation of coaches and athletes. Thus, an effective mutual connection is beneficial to feelings of belonging and valorization within spots teams. Hampson & Jowett (2014) indicate that athlete's perception about affective, cognitive, and behavioral relationship with the coach promotes a higher quality motivation for the athlete to execute tasks and learn new skills. Therefore, the quality of the CAR plays a key role on the student-athlete's motivation at the school sports context.

Despite the contributions to literature regarding the association between the quality of CAR and motivation in the context of school sports, some limitations need to be pointed out. First, students-athletes from only one state (Pernambuco) participated of the present study, which does not represent the reality of the all the Brazilian youth athletes. However, the sample can be considered relevant because the students-athletes participated of the main school competition in the state. The second limitation

refers to the cross-sectional design used in the research, allowing no inferences of causality between the variables. Other limitation was that gender (male x female), modality (individual x team sports) and age group were not compared. In this way, future investigations should continue to explore the association between such variables, analyzing players of other regions of the country and the use of a prospective design, with the aim of establishing new evidences about the association of the quality of the CAR and motivation of young athletes over time.

Conclusion

It can be concluded that the quality of CAR can be considered a key factor for the development of student-athlete motivation (controlled and autonomous) for sports practice. It should be pointed out that the more the athlete has a quality CAR, greater the development of autonomous motivation. However, CAR can also lead to the development of controlled motivation, but with less intensity. As practical implications, the importance of the development of an environment for the relationship based on autonomy, trust, commitment, and closeness on the part of coaches, physical education professionals, as this environment tends to contribute to the development of the adolescent's intrinsic motivation within the context sporty.

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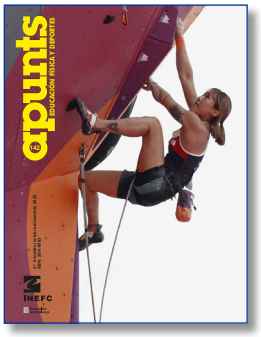

Analysis of Attacking Actions in Professional Men's Padel

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New Olimpic Sports for Tokyo 2020. Climbing. Photo: Climbing. Asian Games 2018. Women's combined final. Competes Kim Ja-in from South Korea. Climbing leader. JSC Sport Climbing. Palembang, Indonesia. REUTERS / Edgar Su.

Abstract

This study examined the distribution of attacking actions in professional padel and their impact on the outcome of the match. The technical and tactical actions shot by shot (n=2,054) of four men's finals on the official World Padel Tour 2017 circuit were recorded by systematic observation. The results showed a solid distribution of shot use between pairs of players in the course of the point (~65% volleys, ~23% bandejas, ~12% smashes) and limited use of attacking actions to win the point (80% in <3 actions). The winners performed a higher number of attacking actions per match. Most importantly, the distribution of the number of attacking actions performed throughout the point was quantified and it was found that the winning pair completed 85% of points with one or more attacking shots and 64% featured fewer than three shots. These results confirmed the importance of volleys as the most used attacking action in professional padel and played more often than smashes. In addition, evidence was compiled about the limited number of strokes available to win a point at the elite level. These data may be useful in setting competition goals and designing tasks which dovetail with the needs of the game.

Keywords: racquet sports, performance, competition analysis, offensive actions.

Introduction

Although padel is a comparatively young sport at just over 40 years of age (Sánchez-Alcaraz, 2013), in recent years there has been an exponential increase in the number of its players to 5.9 % of sports practitioners in Spain (Courel-Ibáñez et al., 2017; Villena-Serrano, Castro-López, Lara-Sánchez & Cachón-Zagalaz, 2016). The reasons for its growing popularity include its social side as it is played by four players and learning its technical aspects is straightforward (Sánchez-Alcaraz, Courel-Ibáñez, & Cañas 2016); the fact that the points last a long time which allows the participants to enjoy themselves to the full (Courel-Ibáñez et al., 2018; Sánchez-Alcaraz, 2014; Courel-Ibáñez & Sánchez-Alcaraz, 2017); it is easily accessible for all sectors of the population because it is cheap; and the proximity of facilities where it can be played to where people live (Muñoz et al., 2016). This growth has also been reflected in the rise in scientific publications (Sánchez-Alcaraz et al., 2015), especially ones concerning performance analysis (Sánchez-Alcaraz et al., 2018). The purpose of performance analysis, also known as notational analysis and match analysis, is to observe, record and analyse the actions and behaviour of athletes in real game situations by compiling information with a high likelihood of transfer to the training field and analysing data from athletes via unprompted behaviour and real competition settings. This information is critical for planning more specific and effective training, designing strategies for better performance and improving decision-making and feedback rooted in behaviour (Garganta, 2009; Hughes & Bartlett, 2002).

One of the most studied aspects in padel and with huge practical applications for training is identifying indicators which enhance effectiveness in winning the point (Courel-Ibáñez et al., 2017; Courel-Ibáñez & Sánchez-Alcaraz, 2018). Previous studies have noted the importance of occupying and maintaining positions close to the net to increase the likelihood of success (Courel-Ibáñez et al., 2015; Ramón-Llin et al., 2013; Torres-Luque et al., 2015). These studies show that more than 80 % of winning points are earned at the net, with the volley being the most common shot accounting for 30 % of total shots in a padel match. This struggle for positions close to the net begins with the first shot of the point, the serve, since one of the features of padel is an immediate approach to the net after the service. Consequently, there is a continuous dichotomy during the course of the point in which the players who are at the net attempt to maintain this advantageous position (Courel-Ibáñez et al., 2017) while the players at the baseline try to regain it (Ramón-Llin et al., 2019).

Nevertheless, although previous studies have quantified the number and type of strokes per point in padel (García-Benítez et al., 2016; Torres-Luque et al., 2015), there are no papers which have specifically examined the offensive actions of padel players and their impact on the outcome of the match. Since this type of action is performed in positions close to the net, this would make it possible to identify the technical and tactical actions which are most effective in maintaining the net position and therefore in increasing the chances of winning the point.

Hence the purpose of this paper was to learn the number and type of technical attacking actions which take place in professional padel and their impact on the final outcome of the match.

Methodology

Participants and variables

The sample included 2,054 technical and tactical padel actions in four men's finals on the official World Padel Tour 2017 circuit. Attacking actions were considered to be shots with no bounce made by the player offensively in a position close to the net (Courel-Ibáñez et al., 2017).

The recorded attacking actions were classified into four different strokes (Courel-Ibáñez et al., 2017), differentiating between ones performed by the winners and losers of the match:

Forehand volley: a stroke before the ball bounces which is performed by the dominant side of the player, usually near the net, with a short racquet swing from up to down, hitting the ball at head height.

a) Backhand volley: a stroke before the ball bounces which is performed by the non-dominant side of the player, usually near the net, with a short racquet swing from up to down, hitting the ball at head height.

b) Smash: a stroke before the ball bounces which is performed by the dominant side of the player, usually near the net. The shot is made with the player's arm extended above their head with a downward arm trajectory. It is a more attacking shot than the bandeja and is a flat shot.

c) Bandeja: a stroke before the ball bounces which is performed by the dominant side of the player, usually further away from the net. It is considered an intermediate shot between the smash and the forehand volley. It is a less attacking shot than a smash and has a slice.

Procedure

Firstly, informed consent was sought from the Ethics Committee of the University of Grenada (No. 883). Next, the videos of the four World Padel Tour finals analysed were downloaded from YouTube®. The systematic observation of

the matches was carried out by two observers with a degree in Sports Science and more than four years of experience as padel coaches who were specifically trained for this task. At the end of the training process, each observer analysed the same set twice with the aim of calculating inter- and intra-observer reliability using Cohen's kappa coefficient, deriving values above .85 which is considered to be a very high degree of agreement (>.80) (Altman, 1991). Specialised Lince software was used for data recording (Gabin, Camerino, Anguera, & Castañer, 2012).

Data analysis

Frequencies (*n*) and percentages (%) were calculated for each variable. Student's t-test was used to analyse differences in the distribution of actions by shot type between winners and losers. Subsequently, differences and interactions in the distribution of attacking actions by number of shots per point (nine categories, from 0 to more than 10) were identified through contingency tables and calculating the chi-square test. The strength of the relationships was interpreted using adjusted standardised residuals (ASR), considering values from 1.96 to 2.58 as small; 2.58 to 3.29 as medium; and more than 3.29 as strong (Field, 2017). The significance level was set at $p < .05$. All the data were analysed using IBM SPSS 20.0 for Macintosh statistical software (Armonk, NY: IBM Corp.).

Results

The winning pair performed a higher number of total attacking actions per match (327 vs. 186). The match winners also performed a significantly higher number of total attacking actions per point ($F > 5.407$; $p < .001$). However, a similar distribution was observed throughout the point, in which the volley was the most used action followed by the bandeja and finally the smash (Figure 1). This latter shot presented the greatest disparities as it was used 5 % more by the winners.

The results of the comparisons by number of actions per point (Table 2) showed differences between winners and losers of the match ($X^2(6) = 54.920$, $p < .001$). The winners performed one or more attacking actions in 85 % of points and in 50 % of cases only between one and two actions. By contrast, the losers failed to perform any attacking actions in 47 % of points. The biggest difference was observed in points with two actions with 14 % more cases in winners compared to losers.

Figure 1
Distribution of attacking actions by shot type between winners and losers of the match.

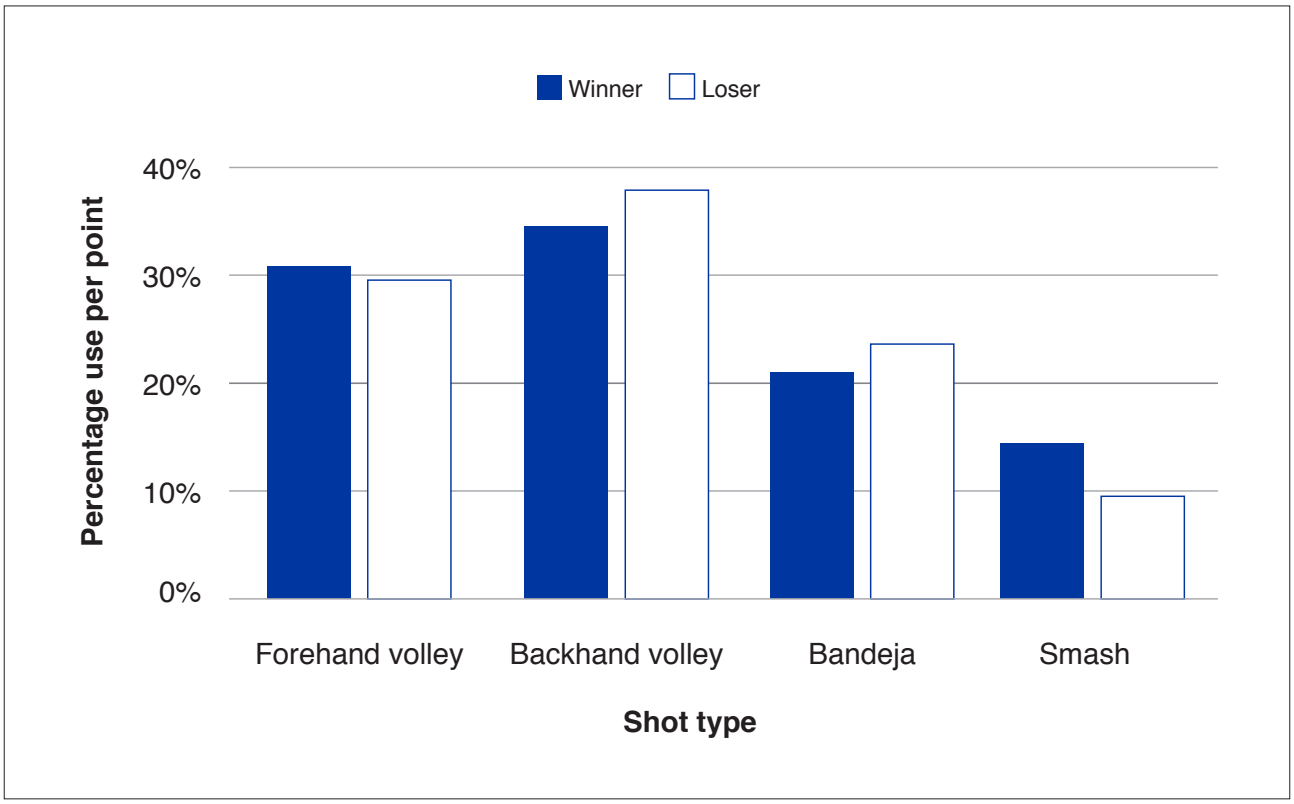

Table 1
Distribution of game actions per point by the final result of the match.

Result		Number of attacking actions per point									
		0	1	2	3	4	5	6	7	8	9 or more
Winner											
	n	71	124	124	60	35	24	20	12	12	4
	%	14.2*	24.8*	24.8*	12.0*	7.0	4.8	4.0*	2.4	2.4	3.8*
	ASR	-11.2	1.5	5.9	2.1	1.8	1.5	2.1	1.4	.9	2.1
Loser											
	n	234	104	53	40	22	15	9	6	8	8
	%	46.9*	20.8*	10.6*	8.0*	4.4	3.0	1.8*	1.2	1.6	1.6*
	ASR	11.2	-1.5	-5.9	-2.1	-1.8	-1.5	-2.1	-1.4	-.9	-2.1
Total											
	n	305	228	177	100	57	39	29	18	20	27
	%	30.5	22.8	17.7	10.0	5.7	3.9	2.9	1.8	2.0	2.7

* Significance of chi-square test ($p<.05$) and ASR>1.96.

The division by shot type (Table 3) showed differences in the distribution of actions per point between winners and losers in all strokes: forehand volley ($X^2(3) = 54.772$; $p < .001$), backhand volley ($X^2(3) = 38.452$; $p < .001$), smash ($X^2(6) = 17.071$; $p < .001$) and bandeja ($X2(3)=63.161$; $p<.001$). The results show differences in the percentages of each type of shot. Firstly, the team winning the point performed more attacking actions per point than the losing team. Secondly, the winning team had a higher percentage in each type of shot in all attacking actions. Thus the forehand volley was the most used stroke in points where there was only one attacking action while the backhand volley was the most used stroke in points where there were two or more attacking actions. The smash was more used by the winning team in one or more attacking actions.

Discussion

The purpose of this paper was to examine the number and distribution of technical attacking actions in professional padel and their impact on the outcome of the match. As might have been expected, the players who performed the most attacking actions per point were the winners of the match. Hence and as previous studies have noted (Courel-Ibáñez et al., 2017; Muñoz et al., 2017), since these actions are executed in the attacking area of the court, players need to try to reach the positions close to the net

Table 2
Distribution of game actions per point by shot type and the final result of the match.

Shot type	Result		Number of attacking actions per point			
			0	1	2	3 or more
Forehand volley	Winner	*n*	244	168	53	23
		%	48.7*	33.5*	10.6*	4.6
		ASR	-7.2	4.4	4.1	1.7
	Loser	*n*	354	105	19	21
		%	70.9*	21.0*	3.8*	4.2
		ASR	7.2	-4.4	-4.1	-2.0
Backhand volley	Winner	*n*	238	149	69	45
		%	47.5*	29.7*	13.8*	9.0
		ASR	-5.9	2.9	3.9	1.9
	Loser	*n*	330	108	32	29
		%	66.1*	21.6*	6.4*	5.8
		ASR	5.9	-2.9	-3.9	-1.9

* Significance of chi-square test ($p<.05$) and ASR>1.96.

Table 2 *(Continuation)*
Distribution of game actions per point by shot type and the final result of the match.

Shot type	Result		Number of attacking actions per point			
			0	1	2	3 or more
Smash	Winner	*n*	238	149	69	45
		%	47.5*	29.7*	13.8*	9.0
		ASR	-5.9	-2.9	3.9	1.9
	Loser	*n*	330	108	32	29
		%	66.1*	21.6*	6.4*	5.8
		ASR	5.9	-2.9	-3.9	-1.9
Bandeja	Winner	*n*	330	115	31	25
		%	65.9*	23.0*	6.2	5.0
		ASR	-4.1	3.4	1.1	1.4
	Loser	*n*	387	73	23	16
		%	77.6*	14.6*	4.6	3.2
		ASR	4.1	-3.4	-1.1	-1.4

* Significance of chi-square test ($p<.05$) and ASR>1.96.

during the padel point to increase their chances of winning the match. More specifically, the distribution of attacking shots showed that volleys are the most used offensive actions and played more often than smashes. These data are consistent with other studies which explored these same attacking shots (Carrasco et al., 2011; Courel-Ibáñez et al., 2015; Torres-Luque et al., 2015)mean ± standard deviation: 16.57 ± 1.51 years and with others which did not analyse the bandeja shot (Priego et al., 2013; Sañudo et al., 2008)varones de categoría nacional (edad, media ± dt: 16.57 ± 1.51 años.

One of the main innovations of this study was the provision of data on the number of offensive actions in the course of a point. It was observed that the winning pair of the match performed one or more attacking actions in 85 % of points. Furthermore, in 50 % of cases they performed only one or two attacking actions per point. By contrast, the losers failed to perform any attacking actions in 47 % of points. The biggest difference was observed in points with two actions with 14 % more cases in winners compared to losers. These data may be related to the limited duration of points in professional padel, which are usually shorter than 10 seconds (Courel-Ibáñez & Sánchez-Alcaraz, 2017; Torres-Luque et al., 2015). It is also important to note that one of the features of padel is the immediate occupation of offensive positions close to the net after the serve (Muñoz et al., 2016). However, recent studies suggest that the advantage of reaching offensive positions following the service lessens after 6-8 shots (Ramón-Llin et al., 2019). Hence these results seem to confirm that professional padel calls for players with the ability to win the point using a low number of attacking actions per point.

The results of this study have some limitations which should be borne in mind when interpreting its findings. One is its small sample size, so it would be useful if future research could replicate this study in a larger number of players to substantiate its results. Furthermore, this paper only examined attacking actions and did not take into consideration other very important variables which may influence the outcome of a padel point or match. These include the prior sequence of actions (both offensive and defensive), the area of the court where the shots are made and their trajectory or efficacy. It is therefore suggested that future research should seek to include these types of variables in order to perform T-pattern analysis of padel actions.

The information gleaned in this study provides benchmarks which may be very helpful in evaluating the performance of padel players. These data will additionally be of great interest to sports trainers and padel coaches when designing exercises with more specific goals, training and strategies to meet the demands and requirements of professional padel. Finally, the importance of training offensive actions in padel, in particular volleys, can be confirmed along with training strategies or tactics to get up to the net in order to dominate the offensive initiative of the point for as long as possible.

Conclusions

Volleys are the most commonly used attack shots in padel and played more often than smashes or bandejas. The pair which manages to perform the most attacking actions during the point has the highest likelihood of winning the match. However, most points (>80 %) are settled using fewer than three attacking actions. This limitation needs to be taken into account when designing training plans and setting goals which meet the needs of competition.

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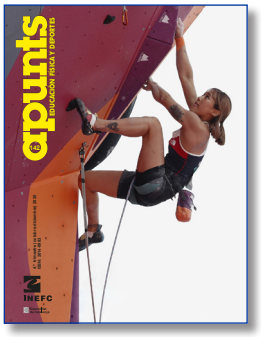

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Effect of Two Periods of Power Training on Performance in the Thrust, Barracuda and Boost Exercises in Synchronised Swimming

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Abstract

The objective of this study was to ascertain the effect of two training periods differentiated by the type of power training (with/without added external load-weights) in synchronised swimmers. The variables assessed were performance (height) on the countermovement jump (CMJ) and on specific boost and barracuda tests. The study participants (n = 10) were a group of swimmers from the children's/junior category (14 ± 1 years) with no experience in power training. During the first preparation period, they were trained without added external load, while in the second period they worked with added external load (lift, squat and weighted jumps). The athletes were tested at the end of the preseason (baseline data) and after each intervention period (14 weeks). The statistical analysis showed significant changes in the boost ($p<.05$) and the thrust ($p<.01$) after the second period. No significant changes were found in the barracuda. No significant change was observed in the first period. A significant positive relationship was found between the boost and the barracuda ($p<.05$) and between the CMJ and the boost ($p<.01$) whenever they were measured. The CMJ and the barracuda presented a positive, albeit not significant, correlation. A significant correlation ($r=.643$; $p \leq .05$) was found between the changes in the CMJ and the barracuda and an almost significant correlation with the boost ($r=.602$; $p=.065$). The results show that training with added external load had a greater effect on the swimmers' performance in the CMJ and that there is transfer to specific actions, probably leading to an improvement in competitive performance.

Keyword: RFD training, assessment, synchronised swimming, CMJ, specific test.

Introduction

Synchronised swimming, or water ballet, is an Olympic sport which combines swimming, dance, ballet and gymnastics. The competitors execute (individually, in duets or in groups) a choreography of elaborate movements in water accompanied by music. This sport is famous for the long periods of apnoea and the characteristic jumps in the water (Hernández Mendizábal, 2015; Mountjoy, 1999, 2009; Peric et al., 2012; Ponciano et al., 2017; Sajber et al., 2013; Zamora, 2015).

It is a sport in which the athlete's performance is assessed by judges, and the aspects evaluated include the precision of positions and transitions, control, extension, height, clarity and uniformity of the moves (FINA, 2017; Hernández Mendizábal, 2015).

In recent years, a more athletic profile is emerging through the inclusion of acrobatic elements in the choreographies, increasing speed of movement and in general requiring that the athletes have a higher capacity to generate rate of force development (Zamora, 2015).

Thus, one of the fundamental skills in synchronised swimming are jumps, when the athletes use techniques specific to this sport to elevate their bodies as high as possible above the surface of the water (Peric et al., 2012).

Justification of the study

The classic concept of power, "any cause capable of modifying the state of rest or motion of bodies, or capable of deforming them", adapted to the field of sport, can be defined as "the muscles' capacity to deform a body or modify its acceleration (starting or stopping a movement, increasing or decreasing its speed or changing its direction)" (González-Badillo & Gorostiaga, 2015). Given the demands of sports competitions, power should be regarded as an extremely important factor. More specifically, the rate of force development (RFD) is the main factor of success in almost all sports disciplines (González-Badillo & Gorostiaga, 2015; Kraska et al., 2009; Suchomel, et al., 2016).

When planning the training process, coaches have to consider a series of questions regarding power training: the possible positive and negative effects, the level of power required for the sport, the time needed to achieve the objectives, the time available, the exercises to be performed, training demands on other qualities and specific training (González-Badillo & Gorostiaga, 2015).

Dryland training sessions are usually needed to develop certain factors that condition performance properly, such as power and flexibility (Mountjoy, 2009). The objective of this training is to produce a transfer effect on the specific actions, leading to improved performance. If one training content or method has no effect on specific performance, coaching professionals will most likely dispense with it. Knowing whether this conditioning work outside the specific medium of competition has the desired effects and leads to improved performance is extraordinarily important and an appropriate battery of tests must therefore be developed and systematically applied (González-Badillo & Gorostiaga, 2015; Gorostiaga, 2015; Suchomel et al., 2016; Uljevic, et al., 2013).

Currently, specific tests are gaining in popularity, particularly since assessing aquatic sports in which the data obtained from tests which are not conducted in the natural medium of competition will be likely to have only a limited application in the water (Sajber et al., 2013; Uljevic et al., 2013).

This study focused on ascertaining the effects of two training periods on power, one without external loads (weights) and the other with them. It was conducted with a single group of synchronised swimmers (14 ± 1 years and 57.14 ± 5.75 kg weight) who were assessed at three different points in the season: a) preseason and pre-test; b) first intervention phase (without added external load) and post-test 1; and c) second intervention phase (with added external load) and post-test 2. The effect of the training was assessed with one dryland exercise, the countermovement jump (CMJ), and specifically within the medium of competition via the height achieved through the specific technical moves of the boost and the barracuda.

The lift, squat and weighted jumps were chosen as the exercises for the power training based on the specific technical pattern of the moves to be assessed. Both the boost and the barracuda are somewhat similar to the vertical jump on dryland. On the one hand, the height in the boost depends on a sudden powerful thrust by the arms coordinated with the extension of the hips and trunk. In turn, although the barracuda is a thrust from an inverted position with a push of the arms, it also requires the energetic extension of hips and trunk (Homma, et al., 2014).

Being aware of the technique of the movements in question, assuming that they are two of the most frequently used moves in synchronised swimming, and related to the rate of force development (RFD) (Peric et al., 2012), the hypothesis was posited that the performance of these two moves in competition would be improved through power training targeting improving RFD on the lower body (measured via the CMJ).

Not only are both the lift and the squat similar to the technical patterns of the moves to be assessed, they also generate high power, and their execution enables the load to move at high speed. Similarly, jumps are also obviously a good exercise for improving it. The best results (Adams et al., 1992; Fatouros et al., 2000) are obtained when both kinds of training are used: a combination of Olympic exercises (or partial ones like the squat and the clean lift) and jumps (González-Badillo & Gorostiaga, 2015).

No scholarly research was found in the literature that studies the efficacy of power training with added external load to improve performance on the CMJ and specific competitive performance in synchronised swimming. Similarly, there are few or no procedures for assessing the specific power required in this sport.

Methodology

Participants

The study sample was comprised of 10 synchronised swimmers ($n = 10$) in the children's and junior categories (14 ± 1 years and 57.14 ± 5.75 kg weight) with three to six years of preparation and no previous experience in power training with added external loads.

Ethical aspects

All the participants were informed of the study in which they were participating and gave their informed consent to participate. The experimental protocol was developed in accordance with the principles of the Declaration of Helsinki.

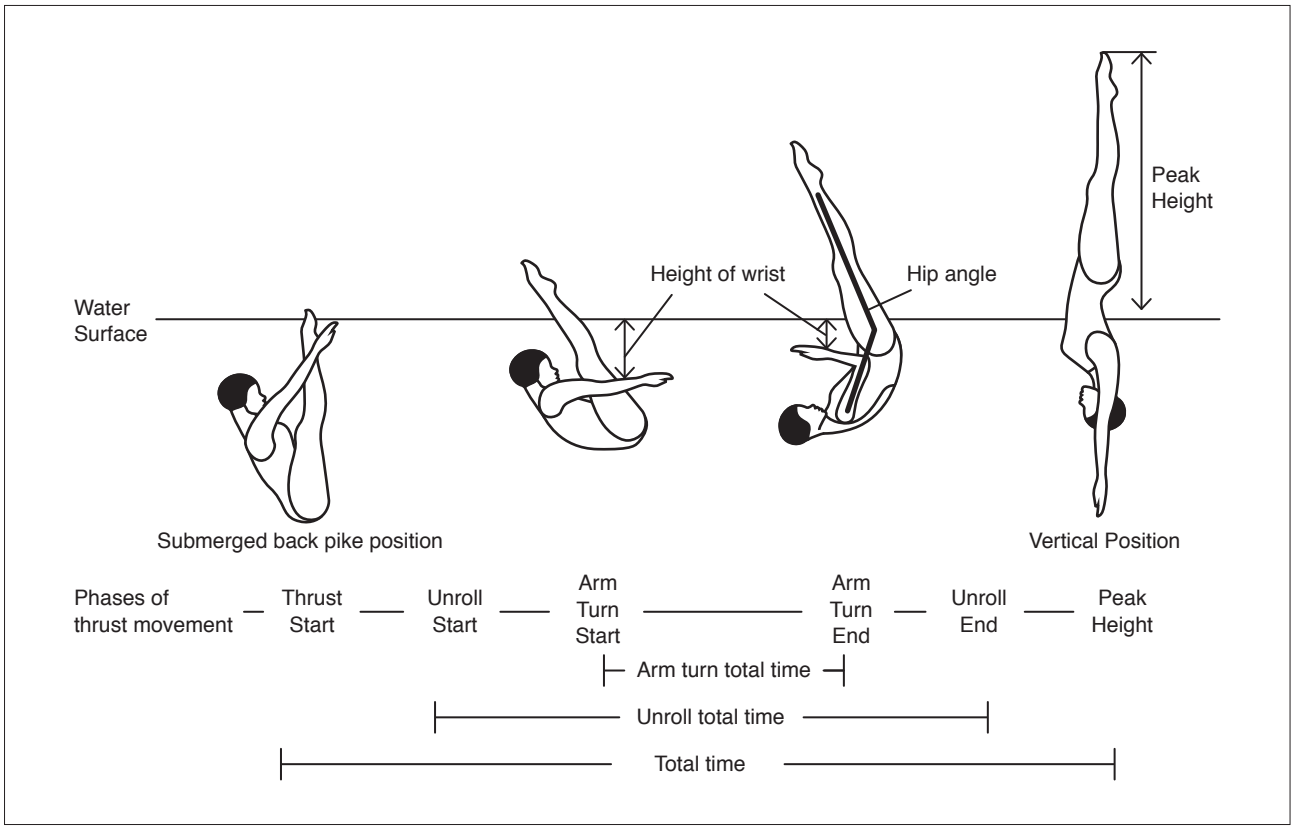
Barracuda and boost

The barracuda and the boost are the two most common jumps in synchronised swimming.

The barracuda is a movement in which the athlete elevates her legs and hips as high as possible from an inverted position.

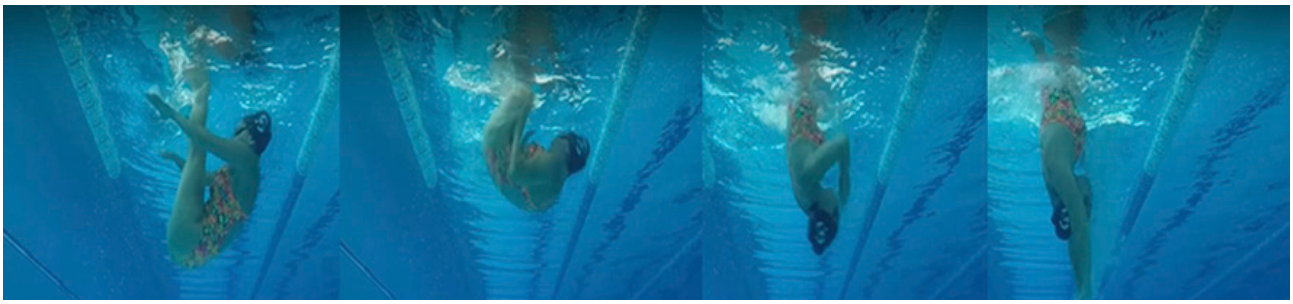
From a frontal extended position (face up, body stretched out with the face, chest, thighs and top of the feet in line on the surface, and with the ears, hips and ankles aligned), the athlete begins to go underwater by moving to a pike position, bringing her legs perpendicular to the surface, and then extending her body (trunk and hips) upward as quickly and as explosively as possible to elevate herself above the surface of the water in an inverted position while also thrusting with her upper limbs (Homma et al., 2014) (Images 1, 2 and 4).

Figure 1
Technical phases of the vertical thrust in the barracuda.



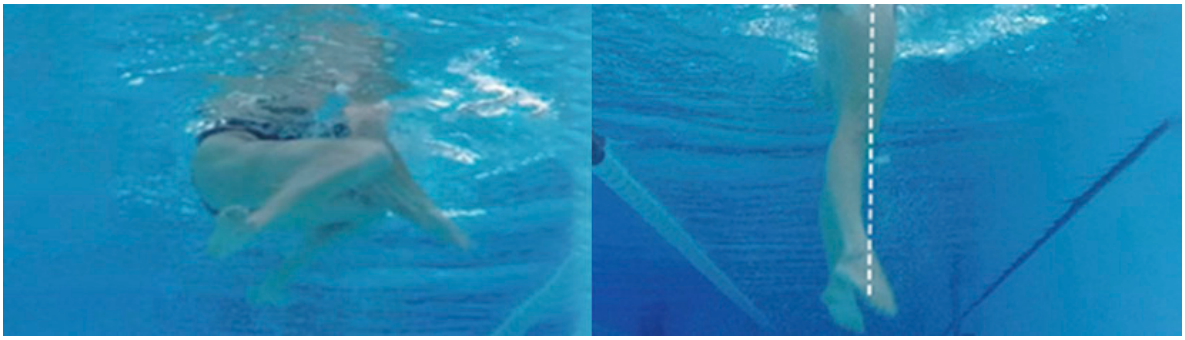
Note: Extracted from Homma et al. (2014).

Figure 2
Underwater view of the vertical thrust in the barracuda.



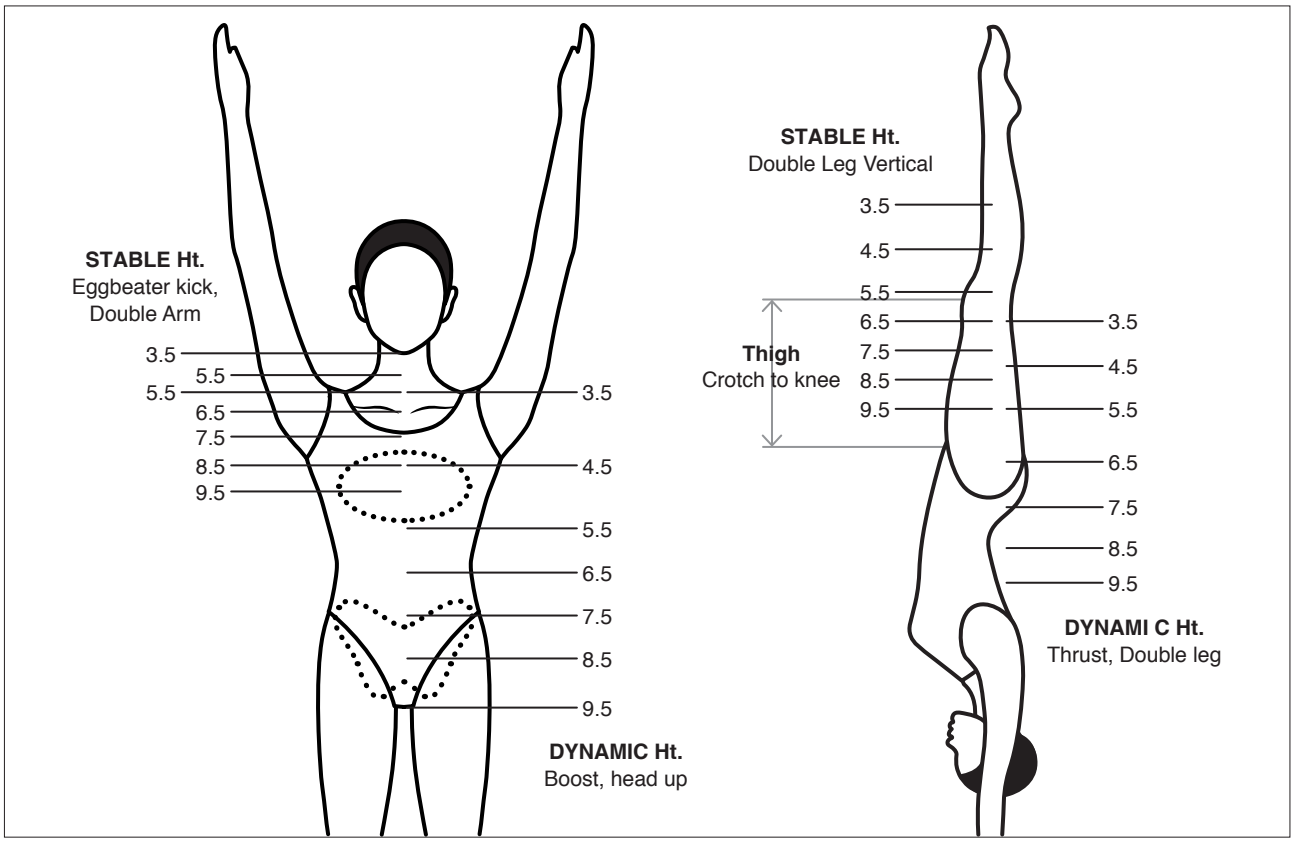
Note. Retrieved from https://synkrolovers.com/ir-mas-alta-hiendo-la-barracuda-la-natacion-sincronizada/?lang=en (07 June 2018).

Figure 3
Underwater view of the vertical thrust, boost.



Note: Fuentes, A. (5 February 2019). Recuperado de https://synkrolovers.com/consejos-natacion-sincronizada-bien-boost-brazos/?lang=en.

Figure 4
Guiding scale for height.



Note: Extracted from FINA manual for judges, coaches and referees (FINA, 2017).

The boost consists of pushing and raising the upper part of the body as high as possible through an energetic arm push and a coordinated, powerful extension of the body with the participation of the arms and elbow extension.

Given their characteristics, both moves are considered to be associated with explosive power (Peric et al., 2012) or with the production of power in the rate of force development (RFD).

Data collection

The objective was to assess and compare the effects of two periods of power training on performance in the thrust, barracuda and boost exercises, while also considering them as a reflection of the athletes' ability to apply rate force of development (RFD).

CMJ

Three jumps per athlete, with a rest time of three minutes between each jump, were recorded on video (Sony α68, 50 fps).

The test corresponding to the CMJ (jump execution) was carried out in accordance with the guidelines described in Bosco, et al. (1983) and Bosco (1994). The move being evaluated was a vertical jump with countermovement, through which they sought to raise their centre of gravity as high as possible through a sudden flexion and extension of their legs and hips, and in this study it was joined by the simultaneous coordinated action of the arms. The athletes were instructed to make contact with the ground after the flight phase in the same way that they lifted off (knees and ankles extended) and to keep their legs and feet totally stretched out during the flight phase. The swimmers' initial position was "standing with the body stretched tall and vertical (without flexing the hips or knees or leaning to the sides or forwards-backwards)" (Bosco et al., 1983; Bosco, 1994; Reyes, et al., 2011).

Based on the filming, the flight time was estimated using the Kinovea (version 0.8.24) software. By ascertaining the time lapse between stills and the number of stills in the flight phase, it was possible to obtain an estimate of the time the athletes were airborne.

The first still was the time when the athletes' feet left the ground and the last image was taken the instant the swimmer made contact with the ground again. To calibrate the time, we input the time lapse between images into the program. This particular camera recorded the jumps at 50 stills or images per second (50 fps). Or in other words, 1/50 of a second elapsed between one image and the next, meaning that there were .02 s between stills. Based on this, we were able to estimate the height reached by applying the following formula (Bosco et al., 1983):

Height reached (h) = $1/2g*(Tv/2)2 = g*(\mathrm{Tv})2/8$, in which g is the gravitational acceleration (9.81 m/s) and Tv is the flight time.

The jumps were filmed in an indoor carpeted area and the jumps were executed barefoot. Camera placement was standardised to ensure that subsequent filming took place in the same conditions as the previous recordings.

Prior to the test, all the swimmers did a standard warm-up: 10 minutes of easy running and joint movement, sprints (4 x 10 m approx.), 3 easy jumps in which they tried to coordinate with their arms, 3 submaximal jumps and the 3 final maximal jumps.

Boost and barracuda

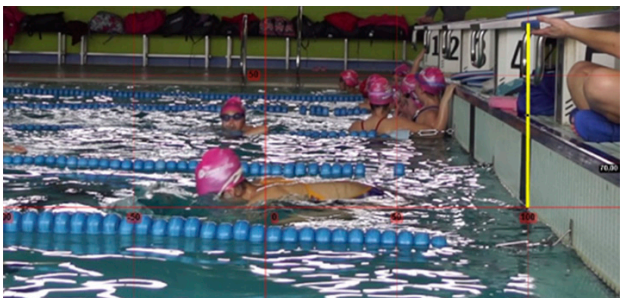
The test was conducted in a 1.8-metre-deep swimming pool. Each athlete did three boosts and three barracudas, with an approximate 3-minute rest time between each move. All the attempts at both moves were recorded on video (Sony 68, 50fps) and subsequently analysed using the Kinovea software (version 0.8.24).

Before the test, the swimmers did a standard warm-up consisting of 100 metres of each style (crawl, backstroke, breaststroke and butterfly) and three practice attempts at the moves being assessed.

Performance in each move was determined by estimating the distance (height) from the surface of the water to the tip of the big toe for the barracuda, and from the surface to the highest part of the frontal bone of the swimmer's cranium for the boost.

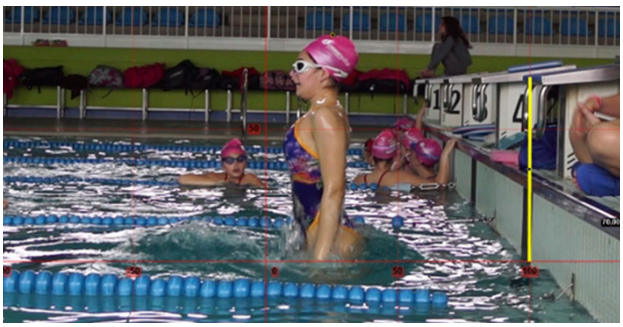
Images 5, 6, 7 and 8 show the initial and final positions of the moves assessed.

Figure 5
Initial position of the boost.



Note: Authors' photo.

Figure 6
Final position of the boost.

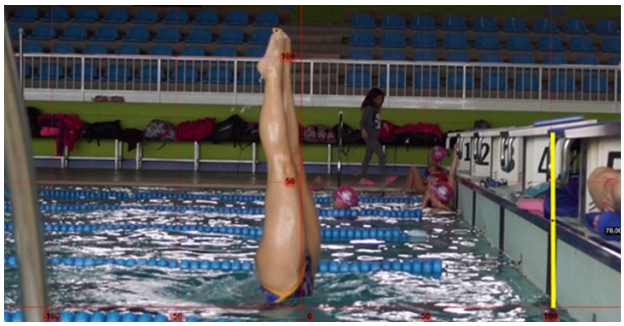


Note: Authors' photo.

Figure 7
Initial position of the barracuda.

Note: Authors' photo.

Figure 8
Final position of the barracuda.



Note: Authors' photo.

For the program to be able to quantify this measurement, the space was parametrised with the height of the starting block with respect to the surface of the water.

The water level was established by the blue marks on the sides of the swimming pool. Therefore, we simply measured from that mark to the near upper edge of the starting block.

Power training

Without added external load.

The exercises used in the power work are presented in Table 1.

With added external load

Before the training, a teaching-learning process was

Table 1
Exercises used during the first intervention period. Without added external load.

Exercises without added external load (without weights)		Series	Repetitions
Bodyweight	Flexions	3-4	8-12
	Pull-ups	3-4	6-10
	Multi-jumps	3-5	5-10
	Plyometrics	0	90-150 jumps
	Isometrics	3-4	30"
	TRX	3-4	10-15
Technical exercises, strokes and propulsive moves with elastic bands	Support scull	3-4	15-20
	Scull stroke	3-4	15-20
	Barracuda propulsion	3-4	10-15
Multiple handball throws	Above the head (throw-in)	3-5	10
	Frontal (chest throw)	3-5	10
	Lateral two hands	3-5	10/side
	Overhead smash	3-5	20"- 30"
	Overhead smash with jump	3-5	20"- 30"
Technical exercises with lower body and breadth of movement (hip)	Dynamic stretches, low-medium speed (flexion, extension, abduction, hip).	2-3	10-15
	Controlled hip flex./ext./abd. up to maximum active breadth (without counter-movement)	2-3	10-15
	Rotation and ext. of hip from 90º abduction	2-3	10-12
	Same exercises as above with load on the ankles or elastic bands	2-3	10
Acrobatic elements	Tiptoes (vertical balance 3 points of supports)		
	Handstand		
	Handstand bridge		
	Bridge with vertical leg		
	Back walkover from bridge		

Table 2
Progression of weights for the squats.

Weeks	Squat													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Series x repetitions	4x12	3x10	2x10 1x10	1x10 2x10	3x10	2x10 1x10	1x10 2x10	3x10	2x10 1x10	2x10 1x10	1x10 2x10	1x10 2x10	3x10	3x10
Load: bar + weight (Kg)	n/l	10	10 15	10 15	15	15 20	15 20	20	20 25	20 25	20 25	20 25	25	25

*n/l: No external load.

Table 3
Progression of weights for the clean lift.

Weeks Semanas	Lift													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Series x repetitions	A.P.	3x10	2x10 1x8	1x10 2x8	3x8	2x8 1x6	1x8 2x6	3x6	3x6	3x8	3x8	2x8 1x4	2x8 1x4	1x8 2x4
Load: bar + weight (Kg)	8	8	8 13	8 13	13	13 18	13 18	18	18	18	18	18 23	18 23	18 23

*A.P.: Analytical practice of the exercise (technical).

Table 4
Progression in the weighted jumps.

Weeks	Weighted jumps													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Series x repetitions	Multi-jumps							4x10	4x10	5x10	5x10	5x10	5x10	5x10
Load	Without added external load							Progression from a minimum of 3-5 to a maximum up to 5-7 kg (increases of .5-1.5 kg/week)						

conducted in which the athletes learned the technical foundations, thus allowing them to do the exercises safely. The 14 weeks of power training with added external load consisted of one weekly session lasting one hour. The exercises chosen were the squat, the clean lift and weighted jumps.

Tables 2, 3 and 4 present the progression and weights planned for the clean lift, squat and weighted jump exercises.

Before starting the weights (kg) indicated for each training session, the subject did two or three series of warm-ups with lighter weights and the same number of repetitions per series, or several more than the number proposed for the maximum weights of each day.

Each repetition had to be performed at the highest possible speed. The recovery time between series was approximately three minutes.

The weighted jumps began in the eighth week, after the athletes had been prepared with multi-jump exercises (plyometrics with cones and benches of different heights, horizontal jumps, long jumps, vertical jumps, bench jumps, etc.).

The weights and progressions for each exercise shown in Tables 2 and 3 were proposed for the subjects who were developing favourably, with the appropriate technical changes in the execution of the exercises. According to the subjective assessment of the ease with which the athletes were capable of moving the weight and the technical quality with which they did it, the weights were increased according to the planned progression, while absolute weight increases were delayed if necessary, as well as the number of series for each weight magnitude.

All the athletes started practising with the same initial weight (weight of the bar) in the squat and lift exercises (bar weight: 10 and 8 kg, respectively). The progressions were in 5-kg increments. In the squat, all subjects worked with the maximum weight of 25 kg. In the lift, the mean maximum weight used was 20 kg (between 18 and 23 kg). The variation between the subjects in both exercises depended on the number of series they did with each absolute maximum weight (between 1 and 3) and the number of weeks in which the maximum weight lasted for each subject.

The athletes' score on the vertical jump test was taken as a reference for selecting the weight for the jumps (their ability to jump higher meant that a higher weight was proposed for the exercise and a higher magnitude of progression, when they were ready). The progression

over the weeks was incremented based on the observation of how they executed the exercise (technique-ease of movement).

Experimental procedure

The study was conducted throughout the season in three phases: a) preseason and pre-test; b) first intervention phase and post-test 1; and c) second intervention phase and post-test 2.

The athletes were assessed through the battery of tests chosen once the season was over (pre-test: baseline or point of departure).

There were five hours of weekly dryland training in the course of the season (28 weeks): one hour of flexibility, one hour of ballet, one hour of specific training for the tests to move up a level (according to the RFEN 2018: "aptitude tests whose purpose is to establish initiation and progression criteria in the speciality"; they provide access to the different national competitions), one hour of power (with and without added external load in the first and second interventions, respectively) and one hour used for core control and specific power (technical exercises, strokes and propulsive moves, acrobatic elements, active breadth of motion, etc.). In addition to the dryland work, the athletes also did their usual pool training.

The first intervention was conducted during the first 14 weeks of the season. At this point, the swimmers did their usual water and dryland training, the latter characterised by power work with body weight and elastic bands. No added external loads were used. The athletes were assessed again at the end of this first period.

In the course of the next 14 weeks of training (second intervention phase), the preparation process consisted of the same type of training that they had already done, albeit replacing the usual power training with the work with added external load (one hour of the five available).

Once the second training period was over, the athletes did the tests for the third and last time.

Statistical analysis

The data are presented as mean ± standard deviation. A repeated measures ANOVA was applied to compare the changes in the different tests. The reliability of the measures was analysed by applying the intraclass correlation coefficient (ICC), the standard error of the mean and its expression in relative terms through the coefficient of variation (CV). The bivariate Pearson correlation coefficient was used to analyse the correlation between the variables and the changes in them. In all cases, a result was considered statistically significant if the probability of error was equal to or lower than 5% ($p \leq .05$).

Results

The assessment procedures showed that reliability was stable. The results were: intraclass correlation and confidence intervals of 95% with .95 (.91-.98), .98 (.96-.99) and .89 (.78-.96) for the barracuda, boost and thrust tests on dryland, respectively, and coefficients of variation of 3.26, 1.76 and 6.43 for the same tests, respectively.

Significant differences were found between the initial test or pre-test and the final test or post-test 2 in the boost in favour of the final test (Table 5). In the CMJ, there are significant differences between post-test 2 and the pre-test and post-test 1, always in favour of the final test (Table 6).

Table 5
Descriptive statistics of the boost test.

Boost	
Assessment	Mean ± DT
Boost pre-test	70.07 ± 9.23
Boost post-test 1	71.69 ± 9.06
Boost post-test 2	72.52 ± 8.60*

** Significant changes compared to pre-test values.*

Boost post-2>boost pre (p<.05).

Table 6
Descriptive statistics of the CMJ tests.

CMJ	
Assessment	Mean ± DT
CMJ pre-test	24.52 ± .043
CMJ post-test 1	24.65 ± .031
CMJ post-test 2	26.57 ± .041** &&

* Significant changes compared to pre-test values.
CMJpost-2>CMJpre (p<.01).
&& Significant changes compared to post-test 1.
CMJpost-2>CMJpost-1(p<.01).

No significant changes were found in the barracuda in any of the tests (Table 7).

Table 7
Descriptive statistics of the barracuda tests.

Barracuda	
Assessment	Mean ± DT
Barracuda pre-test	96.45 ± 11.69
Barracuda post-test 1	93.39 ± 10.67
Barracuda post-test 2	93.89 ± 11.95

Table 8
Correlations between CMJ, barracuda and boost.

	Boost_pre	CMJ_pre	Boost_post1	CMJ_post1	Boost_post2	CMJ_post2
Barracuda	.871*	.561	.638*	.412	.643*	.314
Boost		.784**		.768**		.839**

* $p<.05$; ** $p<.01$.

A significant positive relationship was found between the boost and the barracuda ($p < .05$) and between the CMJ and the boost ($p < .01$) every time they were measured. The CMJ and the barracuda presented a positive correlation, although it never reached statistical significance (Table 8).

With regard to the correlation between the changes, we found a significant positive correlation ($r = .643$; $p < .05$) between the changes in the CMJ and the changes in the barracuda between the post-test 2 and the pre-test, and an almost significant correlation with the boost ($r = .602$; $p = .065$) (Table 9).

Table 9
Correlations between pre-test and post-test 2 changes in the CMJ, barracuda and boost variables.

	Barracuda	Boost
CMJ	.643*	.602
Barracuda		.416

* ($p<.05$)
CMJ-Boost: $p=.06$.

Discussion

The main finding was that the power training led to a significant improvement in the athletes' performance in the tests compared to the absence of changes in performance with the usual training (CMJpost-2 > CMJpre ($p < .01$) and CMJpost-2 > CMJpost-1($p < .01$); boost post-2 > boost pre ($p < .05$)). Although no significant changes were observed for the barracuda, a small change was found compared to the period without external load (Table 7). This improved performance in the CMJ, boost and barracuda tests reflects an increase in the swimmers' capacity to apply the rate of force development (RFD) in these moves.

The minor effect of the intervention on the barracuda may be explained by the absence of a stimulus with external load for the upper limbs. According to Homma et al. (2014), the height of the barracuda depends on the technique of two distinct steps: the one that the authors call "unrolling", meaning the extension of the body from the initial pike position until the complete barracuda extension is reached (which could be improved with this intervention), and the stroke, traction or push, as well as the final thrust, all of which depend on the upper limbs.

We could consider including exercises for the upper body muscle groups in combination with the ones already proposed to gain a favourable effect in barracuda performance.

We also found significant correlations between the scores in the CMJ and the boost, as well as between performance on the latter and the barracuda. The correlation between the direct scores of these variables (CMJ-boost and boost-barracuda) enables us to posit the existence of common features that mutually explain their variances, which could be relevant when power training is programmed (improvement of maximum power and RFD). **

The ICC and CV values showed that the means of the variables studied are stable enough to be valid. Furthermore, the absence of effects after the first intervention period suggests that the changes found after the second preparation series must be related to the power work, thus justifying the positive effects of the training.

No literature outlining procedures to assess specific power in synchronised swimming nor information on training RFD in this sport was found, the sole exception being the study by Peric et al. (2012). These authors suggest the same moves (CMJ, boost and barracuda) as actions that require the swimmers' capacities to express high values of rate of force development (RFD) and they assess the reliability of the same tests used in this study, albeit using different measurement systems, while also seeking to identify relationships between performance in these moves and performance in competition. Their methodology is not the same as ours, since theirs is a descriptive study with a single test with no intervention. Consequently, the results are not directly comparable with the findings of this study. On the other hand, these authors used Cronbach's alpha as a reliability index of the data obtained in the tests. This index is not appropriate in this study, although the intraclass correlation coefficient and the coefficient of variation are, since they are continuous quantitative variables.

No studies were found on the relationships between the CMJ and the moves in the water; therefore, we cannot compare the information obtained in this study with synchronised swimming values. However, the relationships between dryland jump capacity and vertical jump in the

water have been studied in water polo (Platanou, 2005), a move quite similar to the boost in synchronised swimming in terms of technique. Thus, a very minor correlation was found between the dryland jump and the vertical jump in water ($r = .25$) (Platanou, 2005), while in this case, the correlational values between the CMJ and the boost are much higher and more significant (Table 8). The assessment methodology used by Platanou (2005) in the tests is reminiscent of Sargent's test for the dryland jump and assessment in the water. Platanou's (2005) study only provides reliability data on the vertical jump in the water (boost), without mentioning the reliability of the dryland jump. The reliability index for repeated measures used by the author is expressed with "*r*" ($r = .92$-$.94$), which seems to refer to the Pearson correlation coefficient. Once again, this coefficient is in no way valid for expressing the reliability of repeated measures. Therefore, it is also impossible to compare the reliability of the assessment system.

The differences in the assessment methodology used can explain the discrepancies between the results in terms of the correlations between the CMJ and the boost. In this study, the starting angle of the athletes' trunk is as small as possible, as the back is virtually parallel to the surface of the water (Image 5) (the starting position of the centre of gravity is higher, helping the lift) (Sanders, 1999), which enables them to engage the intense participation of the hip extensor muscles, as in the CMJ during the move (Dávila et al., 2012; Luhtanen & Komi, 1978; Vanrenterghem, et al., 2008), while the initial positions of the jump into the water with the trunk location closer to the barracuda, as in Platanou (2005), lower the engagement of these muscle groups, in addition to lowering the centre of gravity. This variation may account for the lack of relationship between performance in the tests in Platonou's study and therefore the discrepancy with the results of this study.

On the other hand, the absence of details in the description of the procedure used to assess the dryland vertical jump prevents us from asserting that the move used is the same as in our study (CMJ, with countermovement), hence the possible variations in the protocol (without countermovement of SJ) may have altered the performance in the test, as well as any possible similarity between the dryland move and the jump into the water, affecting the correlation between scores.

Finally, the concordance of these data with the position of several studies (Peric et al. 2012; Platanou, 2005; Zamora, 2015) is worth mentioning. These studies assert that jumps in water in general, and in synchronised swimming in particular (both the barracuda and the boost), meet the requirements to be moves that are representative of the rate of force development. These results seem to match this approach, given that a positive significant correlation was found ($r = .643$; $p < .05$) between the changes in the CMJ and the changes in the barracuda between the post-test 2 and pre-test, and an almost significant correlation was found with the boost ($r = .602$; $p = .065$). If we consider the CMJ to be a reflection of the athlete's ability to apply rate force of development (Bosco et al., 1983; Kraska et al., 2009; Reyes et al., 2011; Suchomel et al., 2016; Vanrenterghem et al., 2008), and positive relationships were found between this performance and an improvement in the barracuda and boost, this may suggest that both actions are representative of the specific RFD in synchronised swimmers, and that, as found with the data presented in this study, the RFD in synchronised swimming can be improved through an appropriate power training programme.

It could be asserted that a minimum stimulus frequency used for the power work (1 hour a week) is sufficient to improve performance in the CMJ, with a possible transfer effect to the boost and barracuda, most likely leading to improved performance in competition (Peric et al., 2012).

In terms of load dose, particularly in relation to the nature or intensity of the power, we chose a subjective observational methodology to determine both the working weight and the number of repetitions, primarily because there were no other means, although there are reasons supporting this decision. First, estimating the RM, especially in young athletes with no experience in power training, encounters certain limitations and contradictions, including the imprecision of the estimates as a consequence of the inhibition caused by fear or insecurity (which may lead to erroneous conclusions) and the ensuing risk of injury. Secondly, the repetitions assigned to each athlete were determined according to a subjective evaluation of the ease with which they were able to move the load and the technical quality with which they did so throughout the series, giving an idea of the nature of the effort it entailed (González-Badillo & Gorostiaga, 2015).

It should be borne in mind that the effects of this study were observed in athletes with scant experience in power training, which may have led the training to have a greater effect, given that the potential of genetic adaptation had hardly been developed (González-Badillo, 2015). Therefore, the results should only be mainstreamed to a population with similar characteristics, although this does not mean that the positive effects of this kind of training for more highly-trained athletes should be ruled out.

Conclusions

The results suggest that it would be recommendable to include power training with added external load in the synchronised swimming preparation process. More specifically, the clean lift, squat and weighted jump exercises were effective in improving the RFD and the specific RFD of synchronised swimmers (estimated by means of the tests performed).

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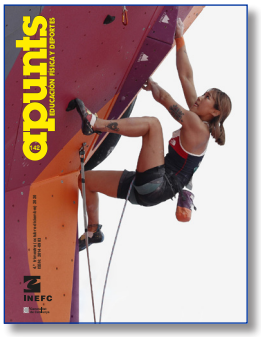

Technical-associative Analysis of the Centre in Winning and Losing Handball Teams

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Abstract

Winning is the ultimate goal of high-performance sports. In handball, a sport in which the number of goals scored is high, identifying the small details and the factors that lead to the team's success is of particular importance to elite athletics. The objective of this study is to identify the technical differences and levels of association with teammates evinced by centres in teams who win and lose in their offensive phase. For this purpose, an observational methodology was used, taking all the offensive actions of the centres in all the matches played during the 2017-2018 Asobal Cup as the sample and creating an ad-hoc instrument called the Inob-FOB to record the data. The validity of the instrument was developed within the Theory of Generalisability (TG). Pearson's chi-squared statistic and polar coordinates were used to analyse the data. The absence of significant differences in the different technical moves analysed (throws: $p<.947$, assists: $p<.408$, executions without loss: $p<.153$, goals scored: $p<.408$) and the results obtained from the polar coordinates analysis reveal that the differences between the players in this position (centres) in teams that win and lose lie in their collective association rather than in their technical performance. These results are relevant for coaches at different competitive levels, since they indicate the type of training they should undertake to improve their teams' collective performance.

Keyword: performance, tactics, polar coordinates, observational methodology, generalisability.

Introduction

In recent years, huge strides in performance levels have been made in the practice of handball due to the evolution of playing systems, as well as the attainment of higher levels of professionalisation in the technical staff and players. As a result, the level of play in the different championships in this sport has improved exponentially (Prudente et al., 2017).

As one of the sports with most practitioners in Europe (Prieto et al., 2015), handball has always aroused – and continues to do so – the scientific community's interest in studying and analysing it from a variety of paradigms. Recently, match analysis is one of the most common paradigms used (Amatria et al.,2020; Daza, 2010; Gutiérrez et al., 2014; Lozano & Camerino, 2012; Lozano, 2014; Lozano et al., 2016, Martín et al., 2012; Montoya, 2010).

The match analysis paradigm encompasses different studies of the positions, technical aspects and tactics during matches or competitions. Since handball is a game in which the players try to score goals (the team with at least one goal more than their rival wins), all the actions and elements involved in the development of any offensive action are relevant and are therefore worth studying.

Part of the evolution that the game has experienced can be seen explicitly in the increasing importance of the frontline players (Montoya et al., 2017), with the player at the centre, aptly called the centre, being tasked with directing and guiding the team's offensive actions and thus playing a key role in interpreting the match and its collective development (Flores & Anguera, 2018).

For all these reasons, and because of the important repercussions of discovering the associative and technical-tactical relations that take place among players on the same team in achieving a high performance (Hristovki et al., 2017), the objective of this study is to compare the technical performance (technical moves by the player in the offensive phase) and associative performance (relationships of cooperation, support and association during the offensive phase) of the players occupying the specific position of centre in high-performance handball on both the winning and losing teams in a highly competitive tournament played for a brief period of time, namely the 2017-2018 Asobal Cup.

Methodology

An observational methodology was used to conduct this study, as it is one of the most highly recommended methods for observing sports, because it studies the spontaneous behavioural interactions of the athletes in their natural setting (Anguera & Hernández-Mendo, 2015).

The design of this study was punctual, with intra-session, multidimensional and ideographic follow-up (Anguera et al., 2011); similarly, observation was governed by scientific criteria with total perceptivity and a non-participant observer.

Participants

The participants were chosen through intentional or convenience observational sampling (Anguera et al., 2011) which included all the players in the position of centre (9 centres) in all the teams participating in the 2017-2018 Asobal Cup (4 teams)..

Observation instrument

The observation instrument used to conduct this study was developed ad hoc for this research and is called the Observation Instrument of the Offensive Phase in Handball (or InOb-FOB; InOb-FOB; Table 1). It combines a field format and category systems (Anguera, et al. 2007), with each one of these systems fulfilling the characteristics of exhaustiveness and mutual exclusivity, as they are nested in the different field formats. Figure 1 shows the map used for the spatial distribution of this instrument.

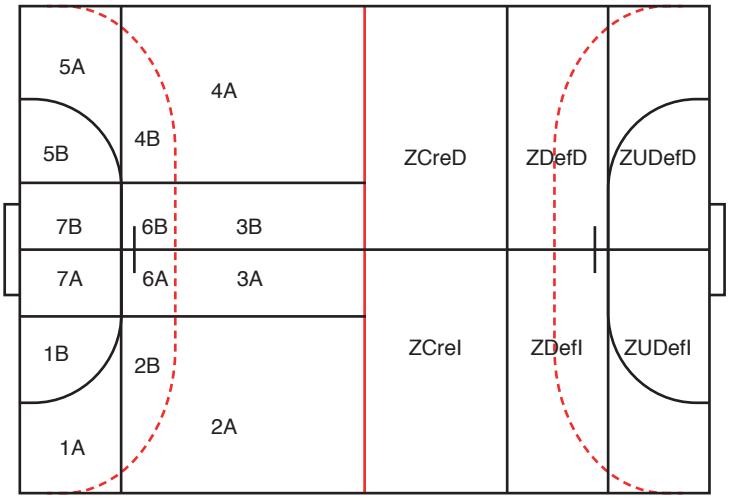
Table 1
InOb-FOB observation instrument.

No.	Criterion	Categories: codes and brief description
1	Register	Obs) Observability; Inob) Inobservability.
2	Match	1) Semi-final; 2) Final.
3	Period	1) 1st part; 2) 2nd part.
4	Player	J1) Player 1; J8) Player 8; J9) Player 9; J10) Player 10; J11) Player 11; J12) Player 12; J13) Player 13; J17) Player 17; J19) Player 19; J21) Player 21; J22) Player 22; J23) Player 23; J24) Player 24; J27) Player 27; J32) Player 32; J34) Player 34; J41) Player 41; J42) Player 42.

Table 1 *(Continuation)*
InOb-FOB observation instrument.

No.	Criterion	Categories: codes and brief description
5	Zone where action starts	ZI1A ZI1B ZI2A ZI2B ZI3A ZI3B ZI4A ZI4B ZI5A ZI5B ZI6A ZI6B ZI7A ZI7B ZIUDefI ZIUDefD ZIDefI ZIDefD ZICreI ZICreD.
6	Zone where action ends	ZF1A ZF1B ZF2A ZF2B ZF3A ZF3B ZF4A ZF4B ZF5A ZF5B ZF6A ZF6B ZF7A ZF7B ZFUDefI ZFUDefD ZFDefI ZFDefD ZFCreI ZFCreD.
7	Offensive system	S33) Classic 3:3 system; S332p) 3:3 system with double pivot; S24) 2:4 system; S43) 4:3 system; S34) 3:4 system; S41) 4:1 system; S32) 3:2 system; S23) 2:3 system.
8	Goalkeeper-Player	A) Left backcourt; B) Centre; C) Right backcourt; D) Right wing; E) Pivot; F) Left wing; NGP) No Goalkeeper-Player.
9	Rival defensive system	SDC) Closed Defensive System; SDA) Open Defensive System; Pres) Individual pressure.
10	No. of attacking players	1J) 1 player; 2J) 2 players; 3J) 3 players; 4J) 4 players; 5J) 5 players; 6J) 6 players; 7J) 7 players.
11	No. of players in defence	0P) Goalkeeper; 1P) 1 player + goalkeeper; 2P) 2 players + goalkeeper; 3P) 3 players + goalkeeper; 4P) 4 players + goalkeeper; 5P) 5 players + goalkeeper; 6P) 6 players + goalkeeper.
12	Offensive situation	IG) Equality; SUP) Superiority; SUPEx) Exaggerated superiority; INF) Inferiority; INFEx) Exaggerated inferiority.
13	Type of attack	Positional, counterattack.
14	Contact with the ball	AT1) reception; AT2) reception + bounce; AT3) reception + bounce + pass; AT4) reception + bounce + throw; AT5) reception + pass; AT6) reception + throw; AT13) reception + bounce + feint + pass; AT14) reception + bounce + feint + throw; AT15) reception + feint + pass; AT16) reception + feint + throw; AT12) reception + loss; AT22) reception + bounce + loss; AT32) reception + bounce + pass + loss; AT42) reception + bounce + throw + loss; AT52) reception + pass + loss; AT62) reception + throw + loss; AT132) reception + bounce + feint + pass + loss; AT142) reception + bounce + feint + throw + loss; AT152) reception + feint + pass + loss; AT162) reception + feint + throw; AT7) pass; AT8) throw; C1) one touch by a player in the observed team.
15	Situation of the action	SUSP) Suspension; APOY) Assist; DRP) Drop.
16	Type of throw	TG) Throw with goal; TB) Throw blocked/intercepted by a player in the rival team other than the goalkeeper; TM) Throw to the posts without goal; TF) Throw out of bounds; TP) Throw blocked or deflected by the goalkeeper.
17	Interruptions	GOL) goal for the observed team; FGF) free-throw for the observed team; FFSB) throw-in in for the observed team; FFSE) corner throw-in for the observed team; FFSP) goal throw-in for the observed team; CGF) free-throw against the observed team; CFFB) throw-in against the observed team; CFFF) corner throw-in or goal throw-in against the observed team; SM) 7-metre throw; DA) play stopped by referee; RA) play resumed by referee; SC) centre throw-in; TPM) dead time; F1P) end of first part; F2P) end of match.
18	Interceptions	P) Loss of ball; R) Recovery; IOC) Temporary interception with continuity.
19	Passive	YES; NO; THREAT.
20	Specific position	PT) Goalkeeper; LTI) Left backcourt; LTD) Right backcourt; CN) Centre; PV) Pivot; ED) Right wing; EI) Left wing; CNTD) Defensive centre

Figure 1
Map showing subdivision of the space.



Recording instrument

Version 1.2.1 of the Lince programme (Gabin et al., 2012) was used to record the data, which are type IV, that is, concurrent and base-time (Anguera, et al. 2011).

Quality control of the data

Data quality was controlled by comparing the records made by two observers quantitatively. Both observers fulfilled the requirements established for recording data by holding a Bachelor's in Physical Activity and Sport Sciences and being handball experts. Similarly, training was provided before the final data recording following the recommendations of Anguera (2003). It should be noted that the recording by the second observer comprises 10% of all the offensive moves. To determine the reliability of the data obtained from the observation instrument, an analysis was applied to find the Cohen's Kappa statistic (1960), whose result quantifies the degree of concordance between the observers while correcting for the randomness factor. The Kappa coefficient was calculated using version 5.1 of the GSEQ computer programme, considering the recommendations of Bakeman and Quera (2011), yielding a concordance value of .90 between the records.

The Theory of Generalisability (TG) was used with version 1.0 of the SAGT software (Hernández Mendo et al., 2016). The phases established by Blanco-Villaseñor (1993) were used for the purpose of designing it, with a two-facet crossed observational plan (3 matches and 181 categories), establishing an infinite universe of data generalisability with a mean of two plans: (Category/Match) to evaluate the generalisability of the results through the number of matches observed, and (Match/Category) to evaluate the validity of the observation instrument created and used by means of TG; the 4th phase, the optimisation plan, proved to be unnecessary.

In the first observational plan (Category/Match), Table 2, the Categories facet presents the highest percentage (78.029%), followed by the interaction of the facets (21.971%). The results of the analysis of this measurement plan confirm the homogeneity of the matches in the observational sample with a relative G coefficient (e^2) = .914.

Table 2
Results of the measurement plan (Category/Match).

Sources of variation	Sum of squares	Degree of freedom	Mean square	Random	Mixed	Corrected	%	Standard error
[Match]	2348.39	2	1174.195	-65.799	-65.799	-65.799	0	7.065
[Category]	27447597.93	180	152486.655	46467.63	46467.63	46467.63	78.029	5338.167
[Match] [Category]	4710154.943	360	13083.764	13083.764	13083.764	13083.764	21.971	972.508

Based on these results, when the "Category" facet is established in the instrumentation facet, the validity of the instrument is verified. Following Lapresa et al. (2020), the instrument is valid when the variability of the "Categories" facet is very high, which means that it is valid when it yields a relative G coefficient equal to or very close to 0. In this case, the relative G coefficient (e^2) is .000.

Data analysis

a) Data analysis by means of the search for the associative relationship between categorical variables

Pearson's chi-squared statistic (χ^2) was used to ascertain the degree of association between the different variables to be analysed, with statistical significance established when the value is $p < .05$.

Version 20.0 of the SPSS statistical package was used to conduct these non-parametric inferential statistics.

b) Data analysis by means of polar coordinates

Polar coordinates are an analysis technique used recently in the study of the sport sciences (Anguera & Hernández-Mendo, 2015). This analytical technique was developed by Sackett (1980) and improved by Anguera (1997), based on Cochran's Q test (1954). This Q test statistic can be used to measure associative consistency between different behaviours, allowing the relationship of activation or inhibition of the conditioning (focal) behaviour and the related behaviours (conditioned behaviours) to be identified. This analysis is conducted both prospectively and retrospectively, yielding a vector for each behaviour related to a given angle and radius. According to the result of the angle, the vector is located in a specific quadrant of the four that comprise this type of analysis. Each quadrant enables us to interpret the relationship between the focal behaviour and the conditioned behaviour. Specifically, vectors in the first quadrant (quadrant I, from 0º to 90º) indicate that both behaviours, focal and conditioned, are reciprocally activated; vectors that appear in the second quadrant (quadrant II, from +90º to 180º) show that the focal behaviour inhibits the conditioned behaviour, but not the opposite; vectors located in the third quadrant (quadrant III, from +180º to 270º) indicate that both behaviours, focal and conditioned, inhibit each other mutually; and vectors in the fourth quadrant (quadrant IV, from +270º to 360º) indicate that the focal behaviour activates the conditioned behaviour but not the opposite.

In this analysis, version 1.5 of the Gseq software was used (Bakeman & Quera, 2011) to conduct the sequential analysis of delays, and subsequently version 1.2 of the Hoisan programme (Hernández-Mendo et al., 2012), where the data obtained in Gseq v5.1 were analysed to obtain the polar coordinates. The computer application Hoisan_to_R, developed by Rodriguez et al., (2019), was used to graphically display the results.

Results

Of the 486 offensive actions analysed, 77% included intervention by the centres, with an intervention percentage of 76.7% in matches in which the team lost and 77.3% in the matches in which the team won.

a) Results of the data analysis by means of the search for the associative relationship between categorical variables

In terms of the number of successful interventions by centres, no significant differences were found ($v = 2.042$; $gl = 1$; $p < .153$) between the outcome of the matches (loss or win) and the success of the technical actions undertaken (success or failure).

On examining the last pass made prior to the centres' execution of a throw on goal, no significant differences were found ($v = .689$; $gl = 1$; $p < .406$) between the end result of the matches (loss or win) and the last pass made prior to a throw on goal (yes or no).

In terms of the number of assists made by the centres, defined as the last pass before a goal, no significant differences were found ($v = .684$; $gl = 1$; $p < .408$) between the outcome of the matches (loss or win) and whether the centre assisted a goal (yes or no).

In relation to the types of throws on goal executed by the centres, no significant differences were found ($v = .733$; $gl = 4$; $p < .947$) between the outcome of the matches (loss or win) and the throws executed.

Finally, no significant differences were found ($v = .684$; $df = 1$; $p < .408$) between the outcome of the matches (loss or win) and the goals scored in terms of the goals scored by the centres.

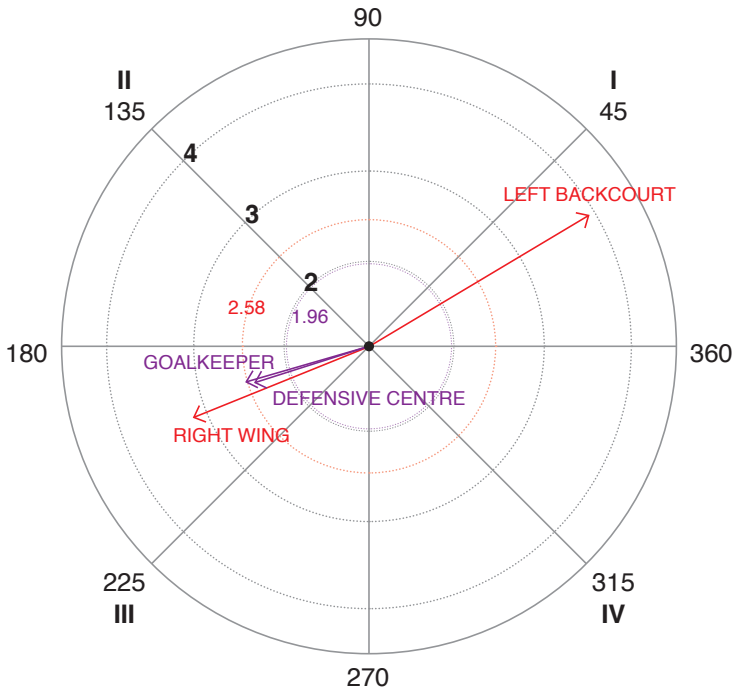
b) Results of the analysis by means of polar coordinates

To conduct this analysis, the CN-centre focal behaviour was related to the other categories that comprise the team structure (PT, LTI, LTD, PV, EI, ED and CNTD). This analysis sought to identify the significant relationships of association found between the centres and their teammates.

Table 3
Results of the analysis of polar coordinates for the CNT, centre focal category, in relation to the other positions when the centre's team wins.

Category	Quadrant	Prospective P.	Retrospective P.	Radius	Angle
POR	III	-2.1	-.66	2.2 (*)	197.51
LTI	I	2.99	2.3	3.77 (*)	37.63
LTD	I	5.03	3.01	5.86 (*)	30.87
PIV	II	-.03	.73	.73	92.44
EXD	III	-3.06	-1.18	3.28 (*)	201.08
EXI	II	-.54	.09	.54	170.54
CNTD	III	-2.03	-.71	2.15 (*)	199.15

Figure 2
Representation of the behavioural map establishing the CNT, centre category, as the focal behaviour in relation to the other positions when the centre's team wins.



With regard to the matches won by the centres' teams, the results (Table 3 and Figure 2) present the LTD-right backcourt criterion category with a radius of 5.86 and an angle of 30.87º and the LTI-left backcourt criterion category with a radius of 3.77 and an angle of 37.63, both vectors in quadrant I, where the focal behaviour activates the presence of the conditioned behaviour both prospectively and retrospectively.

Similarly, the vectors corresponding to the POR-goalkeeper, EXD-right wing and CNTD-defensive centre categories with radii of 2.2, 3.28 and 2.15 and angles of 197.51º, 201.08º and 199.15º, respectively, are all in quadrant III, where the focal behaviour inhibits the presence of the pairing behaviour, prospectively and retrospectively.

In terms of the matches where the centres' teams lose, Table 4 and Figure 3 show the LTD-right backcourt criterion category with a radius of 5.72 and an angle of 31.12º in quadrant I, where the focal behaviour activates the presence of the conditioned behaviour both prospectively and retrospectively.

The PIV-pivot category has a radius of 2.72 and an angle of 161.09º and the POR-goalkeeper category has a radius of 2.61 and an angle of 163.27º, both of them in quadrant II, where the behaviour criterion inhibits the presence of the pairing behaviour prospectively and activates it retrospectively.

Finally, the LTI-left backcourt category presents a radius of 2.61 and an angle of 163.27º, in quadrant III, where the focal behaviour inhibits the presence of the pairing behaviour, prospectively and retrospectively.

Discussion

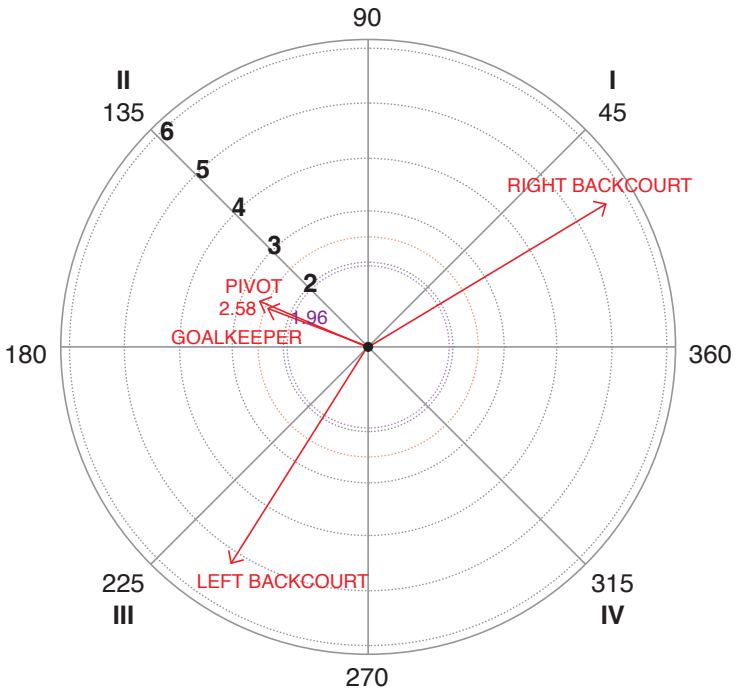
When the intervention and participation of centres in winning and losing teams were compared, no significant differences were found in the execution or effectiveness of throws. These results concur with those found by Vuleta, et al. (2003), who determined that efficiency of throws is a distinguishing feature between winning and losing teams.

In terms of technical moves, neither were there significant differences between the centres in the

Table 4
Results of the polar coordinates analysis for the CNT, centre focal category, in relation to the other positions when the centre's team loses.

Category	Quadrant	Prospective P.	Retrospective P.	Radius	Angle
POR	II	-2.5	.75	2.61 (*)	163.27
LTI	III	-2.92	-4.28	5.18 (*)	235.76
LTD	I	4.9	2.96	5.72 (*)	31.12
PIV	II	-2.57	.88	2.72 (*)	161.09
EXD	III	-.24	-.23	.33	223.36
EXI	III	-.49	-.2	.53	202.43
CNTD	I	.16	.1	.19	31.43

Figure 3
Representation of the behavioural map establishing the CNT, centre category, as the focal behaviour in relation to the other positions when the centre's team loses.



winning and losing teams, which denoted a high degree of technical performance. This was in line with the study by Bilge (2012), which describes the model of play of European handball with a high level of performance and technical variation, and the fact that there were more and more versatile players with higher technical prowess, especially centres. The centres presented higher motor skills (Zapartidis et al., 2011), which concurred with the findings of Foretić et al. (2010), who concluded that throwing efficiency is a feature that sets winning teams apart from losing teams, with the wings and the pivot being the crucial positions in winning.

Furthermore, these positions were associated with the fundamental construction of play (Flores & Anguera, 2018). For this reason, the execution of the last pass prior to the throw, as well as assists before the goal, were core elements in centres' playing performance. In this sense, the absence of significant differences when centres in the winning and losing teams were compared revealed their evident presence in the construction and finalisation of offensive play, in consonance with the results obtained by Gutiérrez and López (2011), whose study analysing the specific positions of the players in the Asobal league identified the importance of the centre in the team's offensive play.

In terms of associative tactics, differences were found in the centres of the winning and losing teams; more specifically, the centres of the winning teams were seen to have a relationship of reciprocal activation with the other players in the frontline of attack (left and right backcourt), affording their game greater variability and complexity and allowing them to make offensive actions by executing and developing complex tactics such as complex tactical procedures and complex tactical circulations, which help to throw the rival defence into disarray. These results match the game patterns found by Flores and Anguera (2018) in their analysis at international levels. It should be noted that the association shown by the centres of losing teams is focused on a single side, meaning that not only do they not use the entire breadth of the court as a resource for tactical performance, but also that their play was predictable and was conducive to defensive action by the rival team.

Conclusion

There are no technical differences or differences in assists, throws or goals between the centres in winning and losing teams, but there are differences when the way they combine with the other players in the team is analysed, with a broader variety of combinations on the part of the centre being found in winning teams, affording greater width and depth to their game by linking up with the accompanying left and right backcourts. However, in losing teams, the centre's combination play focuses on just one side, in this case the right, namely with the right backcourt player.

This study is important for coaches in all categories, given that it helps them to focus their efforts on the degree of combination with teammates and improves their understanding and interpretation of the game, while also suggesting specific tasks in which the offensive game uses the entire width and depth of the court, improving the team's collective performance, rather than simply focusing on the centres' technique at professional level.

Future research into centres' in-game play should be geared towards the collective effect of their movements and the latter's timing, while also taking the rival team's defensive technical and tactical performance into account.

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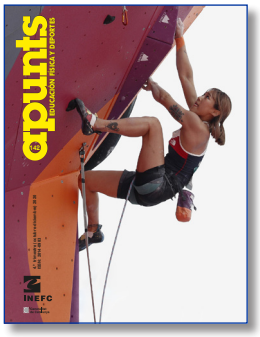

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Training in Team Sports: Optimising Training at FCB

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New Olimpic Sports for Tokyo 2020. Climbing. Photo: Climbing. Asian Games 2018. Women's combined final. Competes Kim Ja-in from South Korea. Climbing leader. JSC Sport Climbing. Palembang, Indonesia. REUTERS / Edgar Su.

Abstract

In the pursuit of sporting success, the main objectives in top-level sport include winning and improving results. The sport sciences constantly strive to apply new training methodologies and systems to enhance and maintain the performance of sportsmen and women. Team sports involve competitions held over long periods of time and also subject the athlete to high competitive stress. They therefore call for methods tailored to their specific features. The methodology called structured training is organised into two areas of action: coadjuvant and optimiser. This article expounds the foundations and the main facets of optimiser training. This publication is part of a set of three articles that explain the basics of the structured training method.

Keyword: performance, physical abilities, structured training, coadjuvant training, methodology.

Introduction

Over the years, the improvement of sports performance in training has prompted the emergence of a number of methodological currents whose common denominator is sporting success. The advent of new theories brought a new training paradigm called structured training (ST), which pursues the all-round development of the sportsman or woman (Tarragó et al., 2019; Seirul·lo, cited by Ribera, 2009). This methodological trend has been innovative in team sports and is particularly relevant for football. Based on the principle that sport-specific training produces better performance adjustments, one of the objectives is to design training tasks which replicate the context and conditions of competition in order to achieve the best possible optimisation of the human athlete's (HA) different structures (Pinder et al., 2011; Tarragó et al., 2019). Figure 1 shows the structures that comprise ST.

In recent decades, FC Barcelona has developed a training methodology for team sports anchored in what is called structured training (ST) (Seirul·lo, 1987; Tarragó et al., 2019), in turn rooted in an interest in the HA: "women and men who are involved in a game/sport who share with others a common interest in winning and in besting opponents to obtain compensation for the effort and dedication required by this objective" (Tarragó et al., 2019).

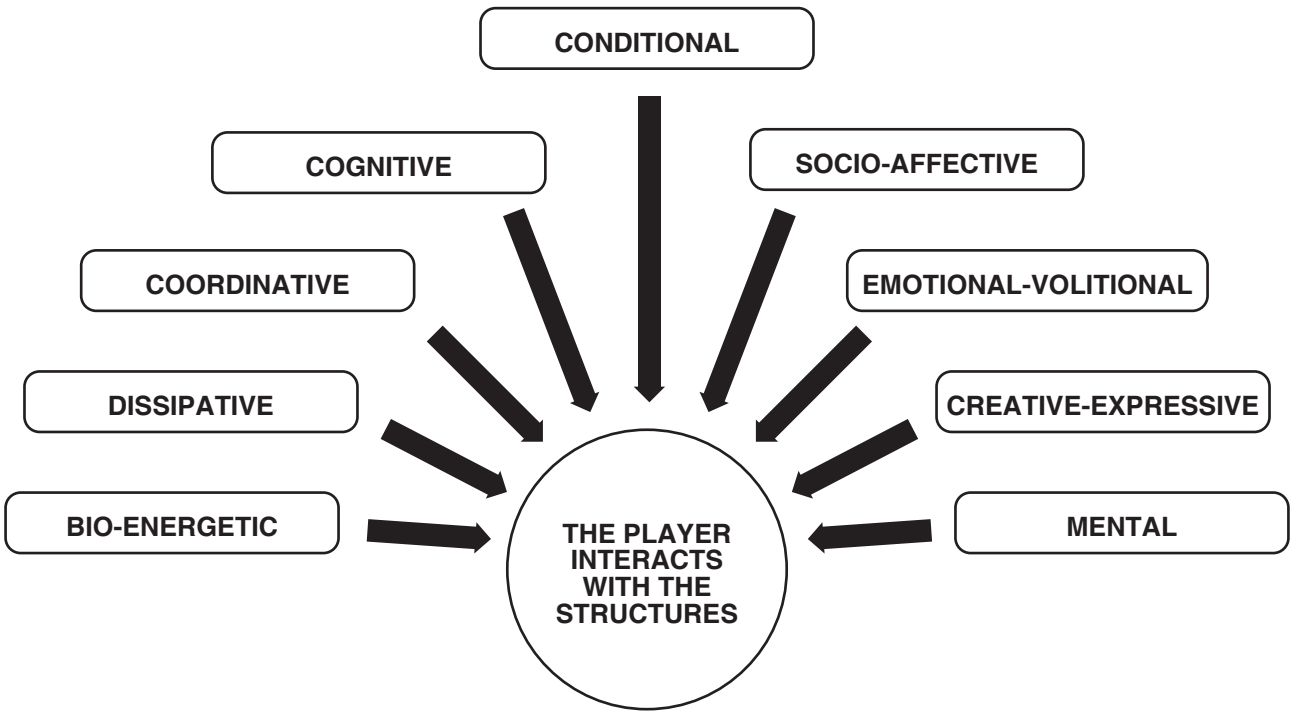
ST is organised on the basis of two paradigms or areas of action, known as optimiser training (OT) and coadjuvant training (CT) (Gómez, et al., 2019), two types of complementary training derived from the theory of complex non-linear dynamic systems (Hristovski et al., 2011; Balagué et al., 2014). From this new standpoint, training constitutes a single process of optimisation of the athlete, i.e. the individual is at the centre and it is therefore he or she who has the capacity to optimise their potential resources (Sánchez & Uriondo, 2012), which entails imbuing practices with a non-linear concept based on self-organisation and variability (Guerrero & Damunt, 2019).

The purpose of this article is to describe the key principles and aspects of OT as one of the two areas of action, together with coadjuvant training (Gómez et al., 2019) for HAs (Tarragó et al., 2019a) developed for team sports at FC Barcelona (FCB).

Optimiser training

Optimiser training (OT) is "training that includes the planning, design, execution and control of the tasks of the sport in question and whose objective is the HA's performance in all the competitions in which they participate throughout their sporting life" (Romero & Tous, 2010, foreword by

Figure 1
Structures that conform the human athlete (HA) in structured training.



Seirul·lo, paragraph 1); "We could say that this training essentially prepares HAs to compete and therefore requires training tasks to be performed in an environment and with elements that are specific to the game" (Tarragó et al., 2019, pp. 105-106), and it is performed primarily on the training ground or court.

Through practice, OT seeks to stimulate and develop the HA's capacities through their structures consistently with their level of development and physical-cognitive maturation, while also taking positional specificity, chronological timing and the features which define the athlete into consideration. OT respects self-structuring and proposes various training tasks and stimuli in an appropriate way, thus consolidating the evolution of the HA and their optimal readiness for competition.

Preferential simulation situations

By using preferential simulation situations (PSSs), OT makes it possible to generate practical proposals that interact with and approach the sport being played. PSSs are about generating events and sets of situations conducive to a state of action and response in a created environment which encourages the imitation of behaviours that simulate the game/sport and preferentially impact the HA's different constituent structures. This preference is achieved through the purpose of the task, which in turn is guided by means of rules, spaces and the number of participating players, which are variable and are tailored to suit the objective. These situations will be defined and extracted by the coaching staff and each player through the analysis and interpretation of the real game (Tarragó et al., 2019).

Given that the objective and foundations of ST are to measure the HA (Arjol, 2012), its practical approach delivers a high level of interaction in the competition of the sport in question. In this context, OT involves an exchange, cooperation and synergy between all the systems that constitute the HA's structures, thereby fostering a different functional capacity which none of these structures separately possesses. This self-organisation corresponds to complex systems' capacity to spontaneously form organisational patterns in the absence of information which imposes order. OT is therefore arranged in micro-structural units by the PSSs (Seirul·lo, cited by Ribera, 2009) and constitutes a specific and differential training practice for team sports.

Using these PSSs, the design of practice situations which are as close as possible to the reality of the game and its internal logic will be examined. This involves generating tasks in which the players have to resolve different situations continually, generating both voluntary and involuntary responses facilitated by extensive practice.

The term "simulation situation" refers to the reproduction of experiences and interactions of game events. The term "preferential situation" suggests the emphasis on or intention to optimise some of the HA's structures. This preference yields a practical situation conceived to accomplish the objective of the session through highly-varied interactions with systems of other synergetic structures.

HAs' characteristics and abilities will inform their training process whilst permitting the development of the structures being challenged by the PSSs. OT involves interactivity, cooperation and partnership between all the systems that make up the HAs' structures. The PSSs will therefore be optimising for the HA and must be presented through global tasks executed preferably in groups and not for the purpose of learning/interpreting the exercise but rather the "game" (Seirul·lo, 2015). In this way, the athlete will be encouraged to focus on the dynamics of the "game" rather than on the rules involved in the task or the instructions of the coaching staff, thereby avoiding not only "playing according to the rules" but also "playing in the content", thus fostering "playing in the context" (Guerrero & Damunt, 2019).

Each PSS calls for the involvement of the HA's different systems or structures which the coach will have to identify. Each player has to bring into play the systems that best respond to the situation created based on their own lifelong self-organisation process. Each HA will deal with this by optimising in a distinct way. OT is about not restricting the exchange of practice with the HA by making it easier to identify basic specific sources of information, such as the determination of the conditional characteristics of the dominant leg, preferential co-ordination patterns in shooting, preferred communication channels, etc., but rather encourages pursuing the attainment of a higher hierarchical level of cognition, relating this intervention to the player's hypercomplexity, for example by addressing the socio-affective dimension, helping them to identify preferential relationships when sharing a mutual intervention/assistance space with a particular teammate.

In recent years, the growing interest in studying the complexity of living organisms and their self-organisation has led to non-linear approaches to learning. It would appear that repeating tasks under the same conditions of practice does not produce the necessary "fluctuations" in the systems involved in order to change their state. Instead, models based on the approach of "constantly changing tasks" through a "variation" in the execution conditions would yield the disruptions required to lead to a change of functionality in the systems involved (Schöllhorn, et al., 2012; Balagué et al., 2014). With introjection and feedback, all the structures that make up the HA can be optimised,

provided that this is done in "repetitions and variations" (Schöllhorn et al., 2015). Consequently, variability and specificity in the stimuli must be prioritised so that the HA can manage them, taking the HA as both a means and an end (Tarragó et al., 2019).

Several authors have classified PSSs by determining a task organisation based on different levels of approaching, specificity and/or concreteness (Moras, 1994; Schelling & Torres-Ronda, 2016; Seirul·lo, 2009). Seirul·lo (1998) classifies strength exercises according to their orientation and level of approach to competition, categorising them as general, targeted, special and competitive. This relationship with specificity in OT is established through the nature of the PSSs, distinguishing them by their general orientation: the nature and organisation of the PSS are similar to those of competition, albeit with a low specific cognitive load; targeted orientation: the nature and organisation of the PSS are similar to competition. This includes specific coordinated actions with non-specific decision-making with a special orientation: the nature and organisation of the PSS are similar to competition with specific decision-making; and competitive orientation: the nature and organisation of the PSS are the same as competition with totally specific decision-making (Solé, 2006).

Conjectures in the preparation of PSSs in OT

PSSs conform the training sessions of the training cycle, which in turn represents the functional unit of ST organisation. This functional unit is called the structured micro-cycle (SM) and manages the cycle between matches. Each micro-cycle interacts with the previous and the following micro-cycle to form sequences of three micro-cycles. Dynamics are established between them in the form of functional relationships between the PSSs of each training day that make up the SM. These relationships are brought about by valid "conjectures" in the configuration of the ST (Seirul·lo, 2015). They are the concepts and assertions supported by signs, observations, symptoms and opinions extracted from the practice of the OT, once it has been accepted and understood that its validity is shaped by the knowledge contributed by the complexity sciences (Arjol, 2012).

The conjectures that determine the preparation of the PSSs are:

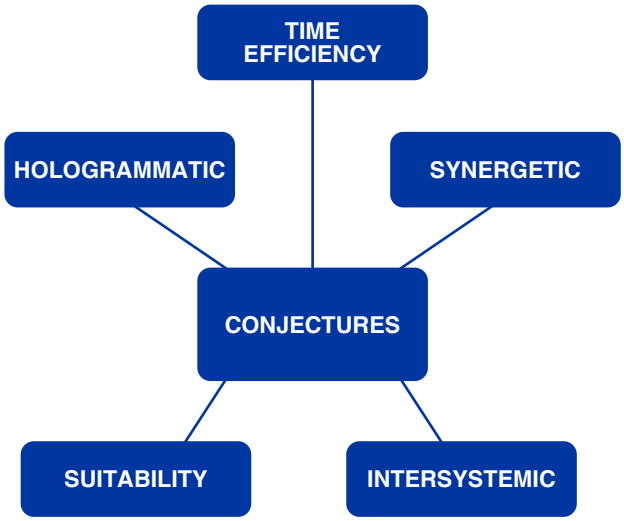
Time efficiency conjecture: defined as the time it takes for a PSS to induce the intended optimising effect on the HA, known as the "shift effect". As the time available in the training sessions is limited, each action is designed to foster efficiency and quality in effort management.

Synergistic conjecture: this refers to the effect achieved by the combination of actions. These synergetic effects are produced between the components of successive PSSs performed in the same session (synchronously) and also across successive sessions (diachronically) within the SM. When a change is sought in the HA, one also talks about the intersystemic effect, to with a system open to the outside world through projection and introjection mechanisms. It is precisely this form of relationship that is called intersystemic when any optimising effect of a system expands its change to other systems of the high structures involved simultaneously.

Suitability conjecture: this refers to the aptitude, good predisposition or capacity that someone has for a specific, adequate and appropriate purpose. The PSSs should be presented in a suitable way to achieve the improvement of the HA in terms of the game's demands. When generating the PSSs it is crucial to identify what is specific and unique to the speciality in which the training is performed in order to understand it in all its entirety and complexity.

Hologrammatic conjecture: this configures the PSSs in OT. It is defined as perceptive capacity (from mind to consciousness) with the ability to capture and gather information that is present, is produced or may be produced during the game. In OT there need to be PSSs where the HA captures and recognises all the situations addressed to acquire them in order to be able to cope with the complexity of the game as efficiently as possible. Figure 2 shows the situations that shape the production of PSSs.

Figure 2
Conjectures that bring about a change in the HA.



Preferential simulation situations

Situation

The PSSs are located in a context that sets up action and response in a game/sport environment comprised of all the elements involved: the athlete, their teammates, opponents, the moment when the action is created, etc. (Balagué et al., 2014). The tasks are global, in groups, and

various time sequences are proposed which are integrated into the complex context of the game (Pol, 2014).

Another key aspect is the specificity of the PSSs used in training. The concept of "specificity" refers to the kind of elements that are specific to a given sports speciality as well as to a specific situational sensitivity on the part of the player as the "own micro-environment" of this game/sport during competition (Tarragó et al., 2019). Drawing on the ST proposal, competition is the event in which all the structures of the HA are most intensively activated, hence the PSSs with the greatest number of stimulated structures within an environment similar to the actual game will have greater specificity.

In recent years there has been growing interest in the complexity of nature and change, which are based on a non-linear understanding of causality, whereby small causes can generate major effects and vice versa (Moras et al., 2018; Tarrago et al., 2019). The PSSs addressed under these criteria not only maintain their essential nature for learning but also become more attractive in practice due to the constant challenge they pose to the HA.

Variability as the basis of OT is the ability to change training conditions to trigger new response learnings so that through these variations the athlete has to adapt their performance and establish new parameters for speed, path, strength, etc. (Schmidt, et al., 2018). This learning is therefore another characteristic element based on the constant resolution of new and varied situations without losing its appearance or preferential objective (Hristovski, et al., 2011). The repetition of specific disturbances typical of the game and of "our game" should be facilitated and can be modified by reducing the degrees of freedom and by means of conditioning and/or constraints (facilitating contexts rather than simplifying them), albeit by means of variable execution. As a complex dynamic system, the player will constantly find themselves in changing contexts to which they will have to adapt continuously. This means the motor behaviour or action to be optimised will not be inflexible and nor will it attempt to follow a pre-established model (Guerrero & Damunt, 2019) while reducing the inherently harmful rate of repetitive practices and increasing the associated creativity. "Adaptability as a product of variability is closely tied to creativity" (Orth et al., 2017).

Simulator

The "simulator" concept refers to the need to use the practical proposal to reproduce the elements typical of the game and which reproduce competition and its specific demands (Balagué et al., 2014). The qualitative orientation of the proposed exercises should be borne in mind in order to convey information that can be identified as having significant value and efficiency for the self-optimisation of the HA (Pol, 2014). The impact on top-level team sports players is usually high.

The use of simulator situations makes it possible to generate exercises of varying specificity or approaching level to the demand (Schelling & Torres-Ronda, 2016), which is related to the planning and control of the PSSs; an adaptation of the load throughout the season helps to plan and generate sequences based on the coach's needs.

Preferential

The "preferential" concept refers to managing the elements of the PSSs in order to distinguish a structure that conforms the HA in the context of OT. This priority leads to a practical situation intended to achieve the objective of the session, i.e. to afford preference/priority to one or more specific structures. This does not mean that this preferential structure rules out any relationship with the others, since the great variety of the game allows interrelationships (Pol, 2014).

It is essential to view the PSSs as a differentiated source of requirements so that even if the same task is proposed for a group of players it does not involve the same level of demands on each one of them; levels of demands have to be adjusted to suit the HA's configuration/shape, bearing in mind specific modifications tailored to individual needs to enable better self-optimisation of each player.

Specific qualities of OT

The distinctive behaviour of each type of sport is determined by the inherent characteristics of the sport/game in question (Seirul·lo, 1998). When considering specific qualities (SQ), a complex relationship is established between the HA's systems which is carried out with movement, through the application of muscle strength. "Strength" means the basic physical quality from which the other qualities are expressed since it is the generator of movement.

OT of the SQs is based on a methodological proposal adapted from Moras (1994), Seirul·lo (1998), Schelling and Torres-Ronda (2016) and Gómez et al. (2019), proposing a breakdown of the game into work areas, contents and alternative training of these contents in accordance with their orientation and the approaching levels that can be attained by promoting each player's technical execution levels (Gómez et al., 2019).

The "work areas" are determined by the four specific expressions of strength required in football and team sports in general: displacement, jump, fight and ball action strength, as depicted in Figure 3 (Gómez et al., 2019; modified from Schelling & Torres-Ronda, 2016).

The PSS proposal in OT includes all the HA's structures, conditioned by the interpretation of the game and the rules of the sports speciality that determine the dominant motor skills and the interactions between teammates, opponents and the environment (Seirul·lo, 1998); all these aspects are strongly influenced by the methodological proposal and the game model implemented by the coaching staff.

The integration of technology into the dynamics of professional teams has made it possible to accurately ascertain conditional characteristics by studying the external and internal load experienced by athletes throughout training and competition (Castellano et al., 2011). Examples include geolocation systems known by the EPTS (Electronic Performance and Tracking Systems) initialism and the semi-automatic, multiple-camera System Technology (VID) tracking systems used in games in La Liga, the Champions League and other competitions. These technological systems make it possible to monitor the actions of the game and to track load based on different conditional variables, thereby simplifying the planning of training units and PSS design. The most recent evolutionary studies of competitive analysis show a significant increase in external load due to high-intensity actions (metres covered at high intensity, number of accelerations, etc.). The relevant information gathered allows objective and efficient action to be taken through OT in response to the needs of the sportsperson vis-à-vis competition. The use of this technology allows the description of the SQs and their behaviour in OT. In line with the suggestion made by Gómez et al., (2019), the expression of strength in all SQs as part of OT and the degree of presence in the performance of sports in shared spaces are presented below (Figures 4,5,6 and 7).

Systems that make up optimiser training of specific qualities. The transition from football to other team sports

Displacement

OT for displacement strength SQ is comprised of all actions on and off the ball, of variable duration and intensity, in which displacement takes place. It includes all types of running (forward, sideways or backwards), changes of direction, turns, feints, accelerations, decelerations, braking, etc., in which the basic principles of the movements focus on precision and on the efficient application of a certain strength in an optimal space and time (Gómez et al., 2019). One of the distinctive aspects with respect to CT and which impacts the SQs is the need to adapt to a changing environment generated by the interactions between teammates, opponents and a ball that alters these relationships continuously.

The implementation of GPS technology makes it possible to identify the speed and amount of displacement of players in regular training and competition. This "intensity" has been classified in several speed ranges in order to evaluate the locomotor conditional demand. By way of example, in a number of football studies (Pons et al., 2019), displacement speed has been categorised in ranges from 0 to 6, 6 to 12, 12 to 18, 18 to 21, 21 to 24 and above 24 kph. Another measurable aspect is the athlete's actions when accelerating or decelerating, which are also expressed in different ranges (Akenhead, et al. 2013). These variables are very important in team sports and are directly related to the HA's neuromuscular structure (Loturco, et al., 2018).

To develop the displacement SQ, a number of game conditions must be considered, affording preference to each one of the situations involved in the sports speciality. The actions which determine the displacement SQ, depicted in Figure 4, are: changes of rhythm (accelerations and decelerations); displacement speed, changes of direction and changes in amplitude and frequency of supports, all of them adapting to the interaction with the environment, opponents and teammates, giving priority to the HA's conditional efficiency.

Figure 3
Specific qualities in OT.

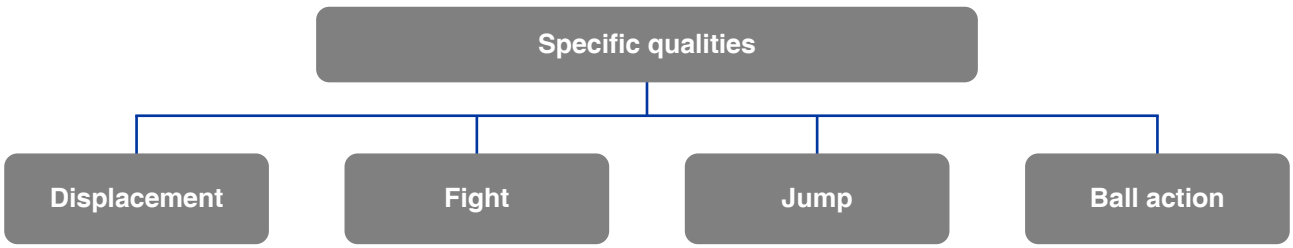


Figure 4
Actions involved in the displacement SQ.

Fight

The fight strength SQ is comprised of all actions on and off the ball, of variable duration and intensity, in which at least two players contest a position or path using part or all of their body to win out, such as ball protection, charging, tackling, losing a marker or fighting to gain a position (Gómez et al., 2019).

Figure 5 shows different actions (before, during and after) to enable the management of the different PSSs, providing variability in fight strength actions. The situations that occur in each sport speciality call for a different application of strength (Seirul·lo, 1998). OT seeks to generate specific stimuli adapted to the sport and each HA based on individual characteristics and taking the positional role into account.

Figure 5
Actions involved in the fight SQ.

Jump

OT for the jump strength SQ is comprised of all actions on and off the ball, of variable duration and intensity, in which there is a jump; this initial thrust can be one- or two-footed, stationary or moving, where the body goes into the air and with a greater incidence in vertical displacement (Gómez et al., 2019).

As an SQ included within the complexity of the game, jumping should be considered as a training component of OT although it is also addressed in CT. Each sport has its own specific jumping characteristics, and consequently game situations in which there are actions in the air (heading and clearances), drives and receptions should be categorised with the diversity of situations appropriate to each sport while taking into account the individual characteristics of the HA.

Figure 6 shows different actions (before, during and after) and their variability in jump strength actions.

Figure 6
Actions involved in the jump SQ.

On-the-ball action

OT for the on-the-ball action strength SQ is comprised of all actions on and off the ball, of variable duration and intensity, in which there is contact with the ball, such as control, dribbling, passing, shooting, clearances, headers, etc. (Gómez et al., 2019).

The action the HA performs on the object varies according to the specificity of each sport when game actions are performed. In terms of on-the-ball actions, passing, kicking and shooting actions, conditioned by the interaction with teammates, opponents and the relationship space, must be taken into consideration.

Figure 7 shows different actions (before, during and after) and their variability in on-the-ball strength actions.

Finally, Table 1 is a summary of the specific qualities and approaching levels.

Future studies and ongoing research should enable further progress in using training methodologies and systems tailored to team sports. The implementation of new technologies for tracking both external and internal loads will make it easier to shape micro-cycles and session and task design based on objective data and criteria. Similarly, research into the relationship between complex systems and sports should be continued in order to buttress strategies which boost their applicability to team sports training and be able to cater to the individual characteristics of HAs.

Figure 7
Actions involved in the on-the-ball ball Action SQ.

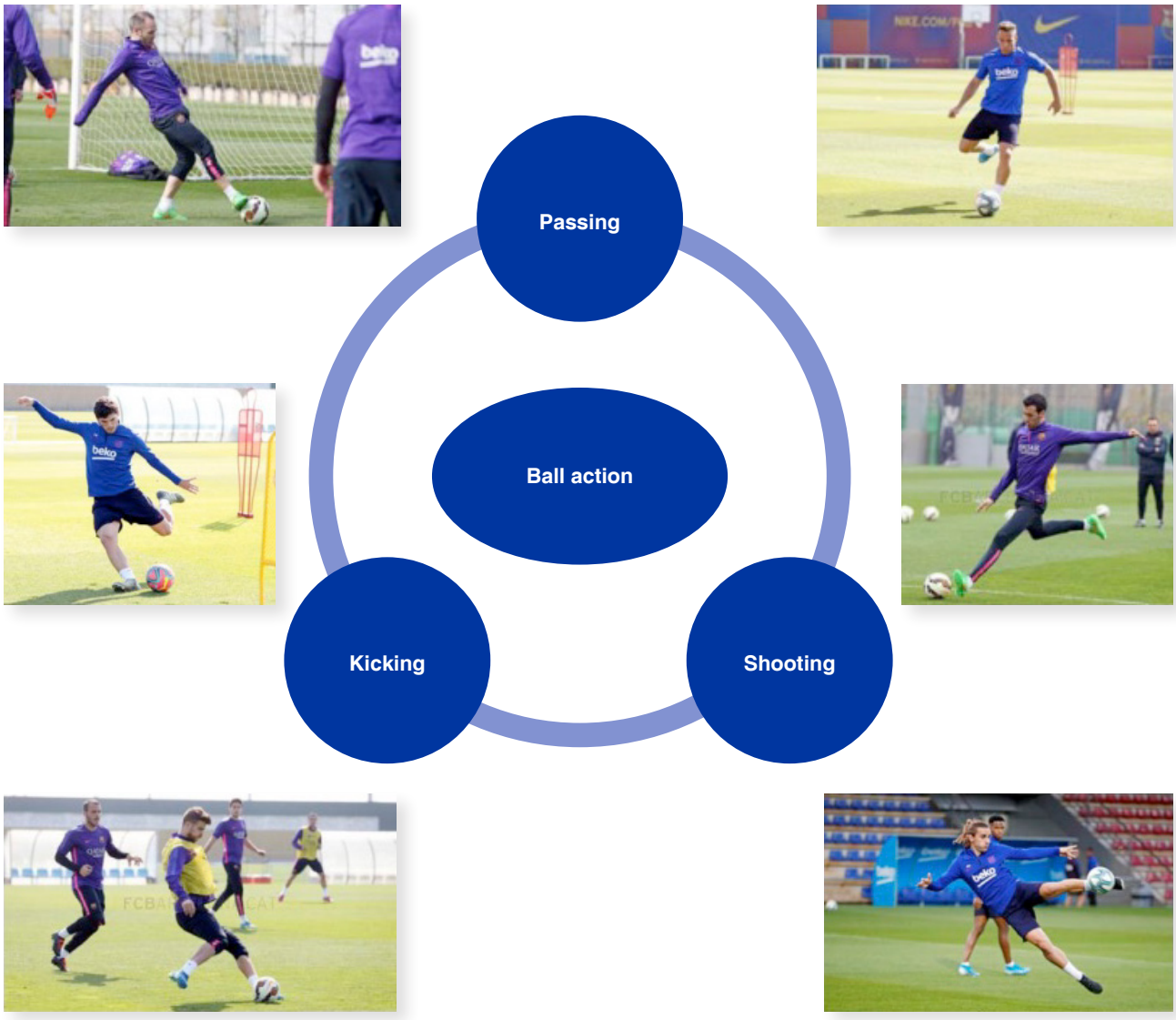


Table 1
Summary table of the Specific Qualities and their approaching levels or nature.

Approaching levels	General	Targeted	Special	Competitive
Displacement				
Changes of rhythm Accelerations / Decelerations Changes in amplitude and frequency of supports Control of running for passing and shooting actions	Linear displacements at different speeds with changes of direction. Displacements between 5-12 m focusing on accelerations and decelerations. Resisted displacements. Displacements over small obstacles. Stride amplitude displacement changes of support amplitude and frequency.	Same actions as general work but introducing a ball, before, during and after. Pass and overlap. Passing sequence. Circuit with combined displacement actions.	Situations played Position game (3v3 + 2) Area 14x12, (4v4 + 3) Area 16x18 (4v4 + 2), Area 18x20 Situation game (5v5 + 3) Area 20x24, (6v6 + 3) Area 22x26 (7v7 + 3) Area 29x25 (8v8 + 3) Area 30x26 Structured SSGs (3v3) (3v3 + 1), (4v4) (4v4 + 1) (5v5) (5v5 + 1), (6v6) (6v6 + 1) LSGs Area ½ pitch, box to box Friendly match	Actual play 11v11 official match situation
Fight				
Throw off balance Grab Push	General proposal for large muscle groups. Self-loading proposal / Medicine ball. Proposal of tasks with partners. Grabbing, throwing off balance and pushing.	Proposal on and off ball in small areas. Proposal for fight game actions with circuits.	Position game Situation game Structured SSGs Competitive units LSGs Friendly match	Actual play 11v11 official match situation
Jump				
Actions in the air (Clearing/heading) Drives (Clearing/heading) Receptions	General proposal for large muscle groups. Proposal with belts, resistance bands. Successive jumps over hurdles with different amplitudes and heights.	Proposal of tasks on and off ball. Proposal of centre and heading tasks in both offensive and defensive actions.	Competitive units LSGs Friendly match	Actual play 11v11 official match situation
On-the-ball action				
Passing Shooting Kicking	General proposal for large muscle groups. Passing tasks with displacements. Accuracy passing tasks.	Rondo. Passing sequence. Circuit with combined passing actions with teammates and opposition with displacements Proposal of tasks with shooting	Position game Situation game Structured SSGs Competitive units LSGs Friendly match	Actual play 11v11 official match situation

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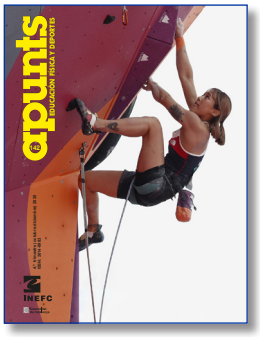

OPEN ACCESS

Analysis of the Safety of Sports Equipment in Compulsory Secondary Education

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New Olimpic Sports for Tokyo 2020. Climbing. Photo: Climbing. Asian Games 2018. Women's combined final. Competes Kim Ja-in from South Korea. Climbing leader. JSC Sport Climbing. Palembang, Indonesia. REUTERS / Edgar Su.

Abstract

The purpose of this study was to analyse compliance with the safety requirements of the sports equipment used in physical education classes in secondary schools in the Region of Murcia, Spain, based on the NIDE and UNE-EN standards and handbooks of best practices. The data were recorded through a series of ad-hoc checklists with dichotomous responses (0=does not comply/1=complies), analysing a total of 582 pieces of equipment owned by the schools in the sample (n=45). The results presented an overall compliance percentage of 70.94±8.44, with hoops presenting the highest rating, with 72.18±12.20, and volleyball standards the lowest, with 65.79±18.34. There were also statistically significant differences according to the ownership of the spaces where the equipment was located and depending on location, i.e. indoors or outdoors. Numerous risks were found in the equipment evaluated, and we therefore recommend that these risks be eliminated or reduced, together with a better monitoring of and compliance with the applicable regulations in order to keep them in a proper state of repair.

Keyword: sport, sports facility, risk management, evaluation, physical education.

Introduction

School sports spaces are the ideal setting for students to acquire physical activity habits (Gil et al., 2010). Therefore, it is essential to have appropriate, high-quality sports facilities and equipment (United Nations Education, Science and Culture Organisation, UNESCO, 2015; Tamayo & Ibáñez, 2006). In physical education (PE), these locations play a fundamental role in the future educational process and are the key tools available to teaching staff (Montalvo et al., 2010; Soriano, 2014).

One fundamental aspect is attending to the safety of this equipment, since although the majority of accidents that take place in school sports facilities are fortuitous, many of them are caused by the improper condition of the spaces and equipment used to practise sport (Barcala & García, 2006). This is inadmissible in today's society if we are to guarantee a quality education (Cabello & Cabra, 2006; Cavnar et al., 2004) and observe the regulatory framework (Instituto de Biomecánica de Valencia, IBV, 2010). Hence, the solution should encompass not only a classification of possible risks but also a better understanding of the aspects that can help to prevent them (Schwebel & Barton, 2005).

In this vein, most of these accidents could be averted if proper safety measures were followed (Adams et al., 2016), and which are needed to preserve not only students' but also instructors' physical integrity to the greatest extent possible (Gallardo et al., 2009; Gómez & López, 2019) through preventive actions (Soriano, 2014). For this purpose, the requirements set forth in the regulations in force must be borne in mind when sports equipment is acquired in order to guarantee passive safety, which is related to compliance with the applicable conditions.

In this regard, Spain has historically lacked regulations on sports equipment, which has influenced both the quality and the practice of sport in general (Durá et al., 2004). Despite this, Lucio (2003) states that in the last decade, considerable legal regulatory developments have been implemented in the field of physical-sport activity, and that while some of these regulations do not specifically correspond to education, their influence in this area is undeniable (IBV, 2010).

Nationally, and while attempts have been made to create a common framework of regulations and conditions to be fulfilled by sports equipment through the "Draft decree regulating the basic safety requirements of sports equipment with multisport courts and multisport pitches" (Consejo Superior de Deportes, CSD, 2009), the actual Decree never materialised. Only the region of Navarre has regulations on the measures required to use sports equipment, through its Regional Decree 38/2009, dated 20 April 2009, regulating the basic requirements and safety measures of sports facilities and equipment.

This lack of regulation has jeopardised not only users, because of the risks posed by the apparatuses, but also the manufacturers of sporting equipment, who face a problem when designing and distributing their products depending on their destination (Durá et al., 2004). However, now, pursuant to the Directive 2001/95/EC of the European Parliament and of the Council of 3 December 2001 on general product safety, all companies must guarantee that the items they sell are safe, meaning that they fulfil the specific national requirements or European Union standards, otherwise they have to take corrective measures. In Spain, this directive was transposed as Royal Decree 1801/2003, of 26 December 2003, on general product safety, which specifies that public administrations must oversee compliance.

In the case of school sports facilities, the minimum requirements of schools that teach the second cycle of preschool, primary and compulsory secondary education are regulated by Royal Decree 132/2010, of 12 February 2010, stipulating that sports facilities at schools must meet minimum safety conditions, just like other teaching infrastructures, although it leaves the specific definition of the requirements up to the applicable legislation.

The requirements for sports equipment are described in the NIDE and UNE standards, which are not obligatory unless thus specified by the authorised administration by law, decree or regulation, or if the competent Administration requires compliance with them in the form of technical specifications in construction projects or procurement contracts. However, given the above, they must be taken into consideration in order to guarantee risk-free sports practice.

Despite this, in recent years several studies have analysed the safety of sports equipment and facilities in schools in Spain, finding numerous cases of noncompliance with the safety requirements (Luis del Campo & Hernández, 2016; Gallardo et al., 2009; Gil et al., 2010; Latorre et al., 2010; Lucio, 2003; Montalvo et al., 2010; Sánchez et al., 2012; Soriano, 2014).

More specifically, in the autonomous community of the Region of Murcia, no studies addressing the safety of sports equipment used in compulsory secondary education were found. However, the studies previously conducted in Spain, as well as the fact that this region is among the lowest-ranked in terms of quality of sports facilities (Burillo et al., 2010), shed some light on a situation that evinces the need to analyse this equipment in Murcia.

With this purpose in mind, the overarching objective of this study was to analyse compliance with the safety requirements stipulated by the NIDE and UNE-EN standards and handbooks of best practices of the sports equipment used in PE classes in public secondary schools in the Region of Murcia.

Methodology

This study was framed within the descriptive, nonexperimental and transversal quantitative methodology through in-situ data collection by means of systematic observation.

Participants

The population of this study ($n = 112$) were public secondary schools in the region of Murcia during the 2015-16 academic year. The participant sample ($n = 45$) was chosen through simple random sampling without replacement for a confidence level of 95% and an error of 5%. It should be noted that seven of the schools initially extracted did not authorise the study, hence sampling was resumed among the remaining schools until the sample size initially determined was reached. The reasons for not participating were, in one school, that they did not have sports facilities, in another that the research staff had no affiliation with the school, while the remaining five simply stated that they were not interested in the study.

Of the schools in the sample, the sports equipment located in their sports facilities and/or the equipment used in affiliated municipal sports venues when they lacked own facilities were examined. In choosing the equipment, we bore in mind the most common types found in conventional sports spaces (goals, baskets and volleyball and badminton standards) and did not analyse the gymnastics equipment since there is hardly, or none at all, in these schools and the use thereof is waning in modern educational programmes (Lucio, 2003). Nor did we examine equipment related to tennis or football, as virtually all of the school sports facilities lacked them, as observed in previous reference studies.

We ultimately analysed a total of 582 pieces of sports equipment, 160 goals, 289 baskets, 95 volleyball standards and 38 badminton standards.

Materials and instruments

For this study, we developed a total of four ad-hoc checklists according to the type of equipment to be analysed, with dichotomous responses (0 = in noncompliance, 1 = compliance). The items were based on the safety requirements of the NIDE and UNE-ES standards, as well as on tools created in previous reference studies (Cabello & Cabra, 2006; CSD/IBV, 2009; Latorre, 2008; Lucio, 2003) and handbooks of best practices (CSD, 2009), choosing only the aspects involving a real and objective risk and which corresponded to use in education.

Depending on the type of equipment to be evaluated, the items were grouped into different areas for each one of the physical parts of the equipment, as well as by aspects related to their stability and sturdiness, and finally by the existence of labelling according to the reference UNE standard.

Once the checklists had been produced, four PhDs in Physical Activity and Sport Sciences, specialised in sports management from three different universities with prior experience in studies similar to this one proceeded to check content validity. Two safety experts from the engineering and architecture disciplines with experience in sports facilities also participated in this study.

Similarly, before the data were collected, the chief researcher participated in a 9-hour training course provided by a specialised company between 11 and 15 April 2016 on the proper use of the measurement instruments used in this study, in the course of which the calibration of the equipment was also checked.

The observers were also trained between 18 and 22 April 2016, beginning with a detailed analysis of the checklists and an introduction to the measurement instruments and procedures. Finally, practical exercises were conducted using images, and interobserver agreement was checked with the Kappa coefficient in the last two sessions, yielding $k > .9$, denoting almost perfect concordance.

A pilot study was subsequently held by the three observers at five schools, after which three items were rewritten to make them easier to understand and two were eliminated since it was ultimately determined that their practical application was irrelevant.

Finally, the definitive checklists comprised a total of 20 items about goals, 26 items about baskets, 20 items about volleyball standards and 15 items about badminton standards.

Procedure

The schools in the sample were contacted by email to explain the rationale, reasons and characteristics of the study and how they would participate. They were

also provided with the contact details of the principal investigator and the institution.

One week later, they were contacted by telephone and furnished with a detailed explanation of the study and to schedule the visits, as well as to appoint the school's contact person.

Data were collected on site by at least two observers exclusively by means of a visual inspection of the sports equipment. The tests for sturdiness and stability provided for in the UNE standards were not performed because of the possibility of damaging or breaking the equipment. Furthermore, these more exhaustive inspections had to be conducted with specific instrumentation by companies approved by the National Accreditation Entity (ENAC).

The evaluation was conducted without interfering in the normal course of teaching in the period spanning 16 May and 2 December 2016.

Data analysis

The data collected during the visits, which came from the printed checklists, were entered into Microsoft® Excel 2007 for Windows spreadsheets on the same day as the visit.

Once the fieldwork had been completed, the data were coded for analysis by means of the SPSS Statistics® v.21 statistical programme. The data matrix was cleaned in order to detect potential recording or coding errors.

Normality tests were subsequently conducted depending on sample size or observations using the Kolmogorov-Smirnov test in cases in which the data obtained were ≥ 50 and the Shapiro-Wilk test when they were lower, in addition to the evaluation of asymmetry and kurtosis; a non-normal distribution was detected and non-parametric statistics were therefore used to analyse the results.

The relational analysis to detect whether possible statistically significant differences according to the ownership of the spaces where the equipment was located and their indoor/outdoor location was conducted by means of the corresponding contingency tables and Pearson's chi-squared.

Results

With regard to the overall results according to the equipment analysed, none of the volleyball or badminton standards met all the requirements, whereas some goals and baskets met all of them.

Regarding the percentage of compliance in each area, the highest rating in goals was for stability, with 92.81%, with only 3.1% not being securely attached. Conversely, labelling-related aspects presented the lowest percentage, with 10.52%, mainly because 12.5% of them only had warning labels and 11.9% markings according to UNE-EN 749.

In baskets, the area with the highest compliance was the hoop, with 93.03%, although this figure fell to 8.89% in labelling requirements, as only 1.4% carried labelling and warnings and 12.6% markings according to UNE-EN 1270.

In the case of the volleyball standards, the aspects related to the sturdiness of the equipment presented a compliance of 95.79%, whereas, as had also been the case in goals and baskets analysed above, only 6.32% carried the proper labelling.

Finally, regarding the badminton standards, sturdiness yielded the highest percentage of compliance, 97.37%, while the net scored only 21.05%, since more than 80% of the equipment evaluated did not have one (Table 1).

Table 1
Percentages of compliance according to type of sports equipment.

n	$\bar{x}$ (SD)	Max	Min	Area	$\bar{x}$ (SD)
Goals					
160	70.38 (12.01)	100	28.57	Frame	80.31 (20.29)
				Net	35.42 (44.18)
				Net attachment	87.67 (16.04)
				Stability	92.81 (21.61)
				Sturdiness	80.63 (36.34)
				Labelling	10.52 (24.98)

Note. [a] No tightener available. [b] Only one item applies, as there are no reinforcement items. Own data.

Table 1 *(Continuation)*
Percentages of compliance according to type of sports equipment.

n	$\bar{x}$ (SD)	Max	Min	Area	$\bar{x}$ (SD)
Baskets					
289	72.18 (12.22)	100	23.08	Support structure	79.53 (19.52)
				Board	43.10 (26.56)
				Hoop	93.03 (19.26)
				Net	56.21 (47.62)
				Net attachment	92.57 (16.36)
				Stability	87.02 (23.85)
				Sturdiness	90.31 (27.19)
				Labelling	8.89 (23.71)
Volleyball standards					
95	65.79 (18.34)	93.75	25	Standards	64.84 (23.10)
				Net	54.74 (50.04)
				Tightener	76.59 (31.49)
				Stability	65.30 (30.24)
				Sturdiness	95.79 (17.36)
				Labelling	6.32 (24.45)
Badminton standards					
38	71.97 (13.84)	90.91	44.44	Standards	77.63 (19.96)
				Net	21.05 (41.32)
				Tightener	No aplica [a]
				Stability	86.84 (32.22)
				Sturdiness	97.4 [b]
				Labelling	26.32 (44.63)

Note. [a] No tightener available. [b] Only one item applies, as there are no reinforcement items. Own data.

Statistically significant differences were found in both goals and baskets, depending on the ownership of the sports space where the equipment was located. More specifically, municipally-owned equipment presented better compliance in terms of the possibility of entrapment; the existence, condition and secure attachment of the net; stability; the state of the structure and the hoop; and the presence and condition of padding. Conversely, there were more anti-tip systems in school-owned goals (Table 2).

Table 2
Significant differences according to ownership of the facility.

Equipment	Item	$\bar{x}$ Ownership		*p*
		Municipal	School	
Goals	6.1.3 No risk of entrapment.	100.0	78.2	.025
	6.2.1 Has a net.	100.0	33.1	<.001
	6.2.2 Net in good condition.	88.9	51.1	.005
	6.3.1 Net attached to post and crossbar.	77.8	46.8	.025
	6.4.1 Has anti-tip system.	77.8	99.3	.001
Baskets	7.1.1 Support structure in good condition.	100.0	81.4	.001
	7.1.7 Open space, obstacle-free.	98.1	86.5	.017
	7.2.1 Board in good condition.	94.2	74.2	.002
	7.2.2 Board protected with padding.	40.4	2.6	<.001
	7.2.3 Pad in good condition.	95.2	33.3	.004
	7.3.1 Hoop in good condition.	100.0	88.1	.009
	7.4.1 Has a net.	100.0	50.2	<.001
	7.4.2 Net in good condition.	100.0	78.0	<.001
	7.5.1 Net attached to hoop.	96.2	65.3	<.001
	7.6.2 Attachment or ballast system in good condition.	100.0	72.8	<.001

Note. Own data.

Table 3
Significant differences according to the location of the equipment.

Equipment	Item	$\bar{x}$ Location		*p*
		Indoors	Outdoors	
Goals	6.2.1 Has a net.	90.0	29.2	<.001
	6.2.2 Net in good condition.	81.5	47.4	.005
	6.4.1 Has anti-tip system.	86.7	99.2	.005
	6.4.2 Attachment system in good condition.	65.4	96.9	<.001
Baskets	7.1.1 Support structure in good condition.	98.3	75.7	<.001
	7.1.7 Open space, obstacle-free.	75.9	97.1	<.001
	7.2.1 Board in good condition.	97.3	65.3	<.001
	7.2.2 Board protected with padding	24.1	.0	<.001
	7.3.1 Hoop in good condition.	100.0	83.6	<.001
	7.4.1 Has a net	94.0	35.7	<.001
	7.4.2 Net in good condition.	94.5	67.2	<.001
	7.5.1 Net attached to hoop.	90.8	45.9	<.001
	7.6.1 Has an attachment or ballast system.	100.0	94.8	.012
	7.6.2 Attachment or ballast system in good condition.	100.0	62.6	<.001
	7.8.3 UNE-EN 1270 marking.	21.4	6.9	<.001
Volleyball standards	8.1.1 Standard in good condition.	94.1	39.5	<.001
	8.1.2 Lack of edges or rims.	100.0	58.1	<.001
	8.1.3 No risk of entrapment.	94.1	62.8	<.001
	8.2.1 Has a net.	76.5	27.9	<.001
	8.3.1 Corrosion-resistant tightener.	92.3	46.2	<.001
	8.6.1 UNE-EN 1271 marking.	17.6	.0	.004

Note. Own data.

Furthermore, statistically significant differences were found in goals, baskets and volleyball standards according to indoor/outdoor location. In this case, equipment located indoors presented a higher percentage of compliance, except in relation to the existence of an anti-tip system, the state of the goal attachment system and the absence of obstacles in the open spaces around the baskets analysed, which was higher in equipment located outdoors (Table 3).

Discussion

The overall mean percentage of compliance of the sports equipment analysed with the regulations was 70.94%. This result is higher than previous reference studies, the majority of which did not reach 50% (Cabello & Cabra, 2006; Herrador & Latorre, 2005; Lucio, 2003; Sánchez et al., 2012), as well as the figures from the study conducted by Montalvo et al. (2010), which did not state specific percentages but did mention poor compliance with the regulations.

In terms of the overall results of each type of sports equipment analysed, two goals were found to meet all the requirements evaluated, while in the study by Lucio (2003), none met all the requirements, although this number rose to seven exclusively in terms of safety criteria. The overall mean percentage of compliance was 70.38%, higher than that of previous studies, which did not reach 50% (Luis del Campo & Hernández, 2016; Sánchez et al., 2012), although the analysis tool and geographic scope were different. It should be emphasised that while 96.9% of the goals are equipped with anti-tip systems and 91.6% of them are in good condition, compliance with these requirements is mandatory, since according to the UNE-EN 15567 standard, an omission may lead to serious injury. Moreover, compliance also precludes regulatory inspection demerits based on the UNE 1920001-1 standard.

In the baskets, as occurred with the goals, two fulfilled all the requirements evaluated, compared to none in the study by Lucio's (2003), although this number rises to 29 if purely safety criteria are considered. The overall mean percentage of compliance was 72.18%, much higher than the mean found in previous studies conducted in other communities, such as the one by Sánchez et al. (2012) which found 40%, and by Luis del Campo and Hernández

(2016), with 53%. However, the findings of our study concur with the latter in that basket equipment presents the highest level of compliance.

With regard to volleyball standards, unlike goals and baskets, none of them met all the requirements evaluated, in consonance with the results of Lucio (2003). The overall mean percentage of compliance was 65.79%, higher than what Sánchez et al. (2012) found, which was under 50%, and amply surpassing the 14% found by Luis del Campo and Hernández (2016), although the findings of our study concur with the latter in that volleyball standards present the lowest percentage of equipment compliance.

Finally, like their volleyball counterparts, no badminton standards met all the requirements evaluated, matching the results of Lucio (2003). The overall mean percentage of compliance was 71.97%, higher than the 62% found in the study by Sánchez et al. (2012), in which badminton standards earned the highest score, although the analysis tools used are different.

Considering ownership of the spaces where the equipment analysed was located, higher compliance was found outside schools. In this regard, Zagel et al. (2019) also detected a higher likelihood of sustaining sport-related injuries at schools compared to outside facilities, citing the higher quality of the sports equipment at the latter as one of the possible explanations.

Despite the existence of regulations and recommendations on equipment safety, noncompliance was detected at all the schools analysed. For this reason, previous studies suggest mandatorily including compliance with the regulations at school sports facilities in order to achieve high-quality sports spaces and equipment (Gallardo et al., 2009; Gil et al., 2010; Montalvo et al., 2010).

In this regard, Luis del Campo and Hernández (2016) argue that while this recommendation would be ideal, the problem would be in adapting all the existing school sports facilities and equipment to these criteria, which would require the competent Administration to provide the relevant economic and human resources, and if they could not do so, the issue of the use of these facilities such would have to be addressed. However, certain criteria contained in the NIDE and UNE-EN standards provide for regulations related to the practice of federation sports and may be partly modified to adapt to schools; nevertheless, safety requirements should be met regardless of the type of sports equipment.

Regardless of initial compliance with the applicable regulations, a periodic check of the condition of sports spaces and equipment is needed (Luis del Campo & Hernández, 2016; Gallardo et al., 2009; Herrador & García-Tascón, 2016; Latorre, 2008; Lucio, 2003; Montalvo et al., 2010; Sánchez et al., 2012) for preventive purposes (Montalvo et al., 2010; Soriano, 2014; Zagel et al., 2019). To achieve this, the teachers of these activities, who are ultimately responsible, must participate in training actions and periodical retraining (Gambau, 2015; López, 2014). Students should also be involved through awareness-raising programmes addressing the risks encountered in physical-sport activities in schools (Latorre et al., 2014).

Conclusions

The objective of this study was to analyse compliance with the safety requirements provided for by the NIDE and UNE-EN standards and handbooks of best practices of the most common sports equipment (goals, baskets and volleyball and badminton standards) used in PE classes in secondary school.

In this regard, numerous safety defects were found in the sports equipment analysed, which could pose risks when they are used. Indeed, none of the equipment at any of the schools analysed met all the requirements.

Similarly, by and large there was greater compliance with the regulations in municipal facilities, and adherence to these regulations is rigorously enforced in facilities intended for public use or for competitive sports, whereas such compliance takes something of a back seat in equipment in schools. Despite the non-competitive nature of the PE subject, safety criteria must be exhaustively fulfilled, as they seek integral student development, which serves as the foundation for future sports practice.

In terms of equipment location, generally speaking greater compliance was observed in indoor sports facilities compared to outdoor venues, as well as better maintenance, hence solutions that offer greater resistance to weather and vandalism should be pursued and equipment checks and maintenance be improved to prevent accidents.

Therefore, according to our results, and by way of a final reflection, we propose the following actions to improve the current situation:

1) A protocol and record of inspections of sports equipment and facilities should be created to facilitate exhaustive, unified monitoring of compliance with the regulations.

2) Training and awareness-raising actions in good practices in the use of sports material and equipment for the entire educational community should be conducted.

3) Actions should be implemented to invest in replacing and purchasing new sports equipment, particularly outdoor equipment.

4) Compliance with the UNE or UNE-EN standards should always be required by the public administration and in the submission of technical specifications for the procurement of sports material or equipment.

Finally, regarding the limitations of this study, and with future interventions in mind, we would highlight the need for it to be conducted systematically at all schools in order to obtain a true picture of the problem.

Similarly, the differences between certain autonomous communities table the need to establish common nationwide protocols and take the relevant regulations into account. By doing so, state-wide data could be obtained through a larger study and actions with a broader scope could be undertaken.

Finally, in addition to the training required to address a problem of this magnitude and the resources needed to be able to act accordingly, it would be worthwhile to focus on investigating new designs of sports material which could at least partly solve the main safety problems and adapt it properly for use in PE classes.

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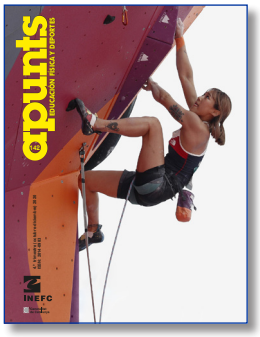

OPEN ACCESS

The potential influence of Cortisol and Testosterone on psychobiological aspects in Paralympic athletes

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Abstract

Paralympic sport is based on performance and requires the planning of physical, technical and psychological training. Factors such as structure, duration and intensity of specific training and disability type might influence hormone levels of blood-free testosterone and cortisol. Few studies have examined the psychobiological aspects in elite athletes with disabilities and their associations with hormonal status. Although there are similarities between the training of elite athletes with and without disabilities, there are certain important variations that take the relationship between hormones and behaviour in Paralympic athletes into account. This article will provide information expanding the level of analysis of close and reciprocal variables involved in the influence of the endocrine system in the psychobiological domains of Paralympic athletes.

Keywords: Para-athletics, Hormones, Sports for Persons with Disabilities.

Introduction

Athletes reach their full physical, technical and psychological potential during routine and systematic training. The interface between psychological and biological factors and their impact on sports performance is an essential factor in preparing an elite athlete.

More specifically in Paralympic athletes, these factors are associated with understanding the nature and extent of the athlete's disability in order to make possible adaptations to the training program (Vanlandewijck, 2006). The Paralympic movement offers a range of sports opportunities for people with disabilities, considering neuroanatomical differences according to the types of functional diversity present in different athletes, such as impaired muscle power or passive range of movement, limb deficiency, short stature, visual and/or intellectual impairments (IPC, 2015).

Despite the growth of the Paralympic movement in recent years, research has focused primarily on the preparation of elite athletes and their peak athletic performance. One emerging area of research includes the interactions between biomarkers and behavioural factors.

This question can generate new knowledge regarding the use of this information in training. In this scientific note, perspectives will be presented to encourage researchers to further our understanding of the interaction between behavioural and physiological factors in the Paralympic athlete.

1.*Factors influencing sports performance in Paralympic athletes*

Paralympic athletes depend on factors such as the equipment used (prosthetic devices, wheelchair, etc.) and the interface between the athlete and their gear (Vanlandewijck et al., 1999). Additionally, the athlete's biological and psychological state and the modality (Paralympic categories and functional classifications) are also essential in improving sports performance.

Usually, the interaction between biological and psychological factors influences any improvement in sports performance. The study of biological factors seeks to understand the morpho-functional characteristics (physiological functionality, metabolic and/or neuromuscular) resulting from impairment (acquired or congenital) which directly influence the athlete's motor behaviour (Vanlandewijck, 2006).

One example is the condition of autonomic dysreflexia associated with spinal cord injury (SCI), characterized by an exacerbated response of the sympathetic system and a lack of control over the parasympathetic system (Krassioukov, 2009). As a rule, autonomic dysreflexia occurs when a spinal cord injury occurs above the thoracic vertebrae T5-T6 (Krassioukov, 2009) and it can be induced by stimuli such as bladder distention or the application of tight leg straps (such as in rugby wheelchair athletes and wheelchair distance racing).

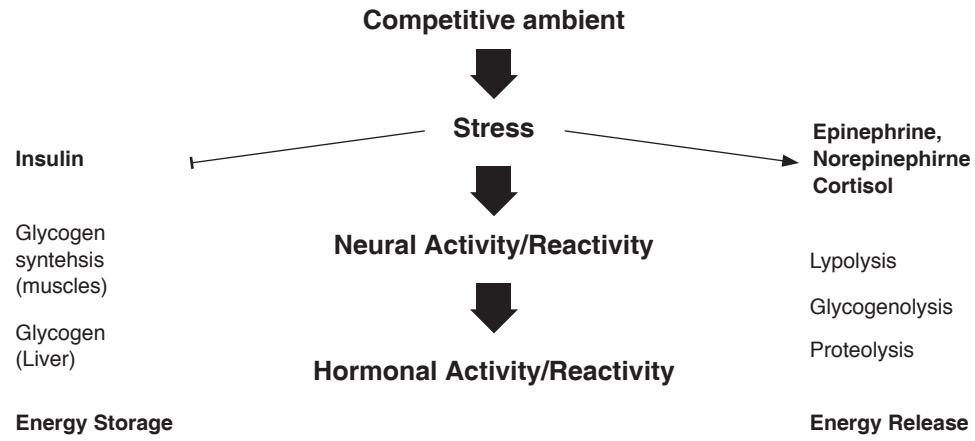
Regarding psychological factors, disabled persons with acquired disabilities tend to develop sports expectations with a stronger connotation of overcoming their impediment compared to their peers with congenital disabilities (Samulski et al., 2011). Indeed, knowledge of the psychological factors related to impairment offers a major contribution to the beginning and continuation of the sports training process.

The impacts caused by disability could lead these individuals to have higher levels of anxiety and insecurity in the face of certain situations, arising both from the conditions of daily life and the demands of the sport (Samulski et al., 2011). For this reason, an interdisciplinary intervention (coach and sports psychologist) may be positive for the development of the athlete's skills.(Riera et al., 2017).

2. *Interaction between the cortisol and testosterone biomarkers and psychobiological aspects*

The human body is dynamic, and the biological system is influenced by environmental factors that inhibit or stimulate hormone production and release (figure 1).

Figure 1
Interaction between the cortisol and testosterone biomarkers and psychobiological aspects.



Certain metabolic and hormonal changes have been described in persons with congenital or acquired disability. For example, in SCI conditions, plasma noradrenaline and adrenaline levels may be increased during autonomic dysreflexia episodes (Leman et al., 2000). Other important hormones may be changed in disabled people.

Cortisol (CORT) is an essential primary human glucocorticoid hormone in the regulation of glucose and is produced due to stress, depending on the circumstances and on the psychological status of the individual. The activation of the hypothalamic pituitary adrenal (HPA) axis, with the release of CORT, reflects the affective component of the individual's experience (Frankenhaeuser, 1991).

From the endocrine standpoint, in competitive situations (sporting events) the stress response is triggered before the start of the competitive activity. This sharp increase performs a particular function in preparing for competitive adjustment (Kivlighan et al., 2005). However, research into the link between the concentrations of CORT and psychobiological aspects in athletes with disabilities is lacking.

In addition to CORT, another potent steroid hormone with psychobiological effects is testosterone (TEST). The motivation of competition can be related to the impact of endogenous TEST in the central nervous system, and some studies show different levels of TEST in winners and losers during and after competition (Fry et al., 2011) and in athletes competing at home compared to those competing away (Carré, 2009).

3. *Resting hormonal changes in people with disabilities*

Some studies have suggested a high prevalence of TEST deficiency in men with acute SCI (less than four months since injury) (Schopp et al., 2006). Low TEST rates have been reported in men with chronic SCI when compared to age-matched non-disabled men (Bauman et al., 2014).

In a general context, 80% of people with SCI are male, justifying the higher output of scientific research focusing on the demands of this biological sex (NSCIA, 2016). However, there are few studies investigating the effects and consequences of SCI in hormone levels in women. A study conducted by Dirlikov et al. (2019) presents thyroid function and testosterone levels in women with SCI. The results showed that low total TEST was associated with depressive symptomology after accounting for time since injury. The same study highlights the need for further research in order to elucidate the concerns of women after SCI.

A combination of comorbidities, medication, and obesity could be partly accounted for by the decline in serum TEST, amplifying the age-related changes in the secretion of this hormone (Bauman et al., 2014) or associated to the stress and comorbid trauma associated with SCI (Schopp et al., 2006).

Visual impairment also changes hormonal status, because ocular light exposure is a powerful environmental circadian synchronizer. The studies conducted by Bodenheimer, et al. (1973) reported some abnormalities in TEST and CORT production in a majority of blind men.

Changes in TEST and CORT hormone levels can modulate psychobiological responses. Low levels of TEST are associated with lack of energy, lack of motivation and reduced libido (Kelleher et al., 2004). Besides hormonal changes in resting conditions, exercise may influence catecholamine concentration and the secretion of blood-free hormones in individuals with disability (Rosety-Rodriguez et al., 2014).

4. *Exercise responses in cortisol and testosterone levels in disabled athletes*

In elite sport, there are certain similarities between the training of elite athletes with and without disabilities. It has been documented that hormonal changes (mainly TEST and CORT) during a challenge in non-disabled athletes could interact with their personality traits to improve their competitive performance (Parmigiani et al., 2009). However, there are significant differences that should be considered in the hormonal patterns of Paralympic athletes.

Catecholamine release is affected in people in whom the high-cervical and thoracic nerves are disabled (C1- T1) due to the suppression of neural pathways for sympathetic pathways and adrenal gland dysfunction (Leicht et al., 2013). Thus, some evidence of a hormonal variation altered by hormonal axis function which directly influences hormone concentration during and after physical exercise has been observed.

Conclusion and Outlook

Fluctuations in behavioural factors during the competitive season are likely to occur due to training, performance and expected results. The use of questionnaires is practical, and large amounts of information can be collected at a relatively low cost. However, the information provided by surveys might not suffice to understand some forms of variables - i.e. changes of emotions, behaviour, feelings, etc.

Monitoring hormonal status (TEST/CORT) might allow psychologists, sports scientists and sports coaches to gain more extensive and more precise knowledge of the psychobiological responses of athletes with disabilities and to understand behaviour regulation better. For example, these biomarkers could guide both training (affective responses) and motivational strategies (coping). However, certain limitations inherent to Paralympic sport (diversity and heterogeneity of the athletes with regard to disabilities and functional classifications), biological sex and specific physiological characteristics resulting from impairment

(acquired or congenital) must be considered in order to achieve a better understanding of this link between these biomarkers in psychobiological variables.

Some studies have investigated the use of the TEST/CORT ratio, utilizing plasma or serum levels, to monitor athletic performance. The use of saliva as a collection tool is reported to be advantageous as it is safe and non-invasive and has a close correlation with serum levels (Papacosta & Nassis, 2011)

In other words, the practical implications of monitoring TEST and CORT might allow a multi-parameter evaluation (psychological and biological) of variables that determine the athlete's performance during the training or competition period. Thus, we hope to stimulate a discussion that could lead to a greater understanding of the different aspects involved in behaviour and the influence of hormones (TEST/CORT) in the physical and psychological domains of Paralympic athletes.

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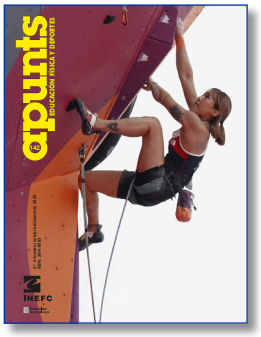

OPEN ACCESS

Most Demanding Passages in Elite Futsal: An Isolated or a Repeat Situation?

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New Olimpic Sports for Tokyo 2020. Climbing. Photo: Climbing. Asian Games 2018. Women's combined final. Competes Kim Ja-in from South Korea. Climbing leader. JSC Sport Climbing. Palembang, Indonesia. REUTERS / Edgar Su.

Abstract

The main purpose of this research was to examine not only the most demanding passages (MDP) of elite futsal matches through different external load variables: total distance covered (TD), distance covered at high-speed running (HSR), metres covered above 0.02 Player Load (PL), number of high-intensity accelerations (ACC) and decelerations (DEC); but also to analyse whether they may be repeated in the course of a single match for a single player. Data from one professional futsal player were collected using a local positioning system from a total of twelve official matches of the 1st Division of the Liga Nacional de Futbol Sala (LNFS) during 2018-2019. The rolling average method was used for all variables, using a one-minute time window. Data were re-analysed to identify the very high demanding passages (VHDPs; >90% of the mean of the three top MDP of all matches) and the high demanding passages (HDPs; 80%-90% of the mean of the three top MDP of all matches). The results showed that the VHDPs and HDPs in a single match did not present as an isolated situation. TD and ACC were the two most demanding variables in terms of repetition of HDPs and VHDPs.

Keywords: Team sports, high demanding passages, external load, game analysis, UWB.

Introduction

Monitoring players' exposure to training and competition loads has become a regular activity in the daily work of sport scientists and strength and conditioning coaches. Recently, increasingly greater attention has been paid to the most demanding passages (MDPs) of matches in different team sports, with several studies using different methodologies such as dividing the match into predefined periods of 15 minutes (Carling & Dupont, 2011) or 5 minutes (Bradley & Noakes, 2013; Di Mascio & Bradley, 2013) and the rolling average method in different team sport research (Delaney et al., 2017; Fernández et al., 2020; Malone et al., 2017). An MDP of a match could be described as a multifactorial phenomenon that occurs within a defined time period, in which all the conditional and emotional variables are more demanding than at any other moment in a game (or training session) (Fernández et al., 2020), and the rolling average method seemed to be the best method for describing these scenarios (Delaney et al., 2017).

Hitherto, most of the studies that have addressed MDPs have sought to identify only one scenario per match, without entertaining the possibility of having 2 or more scenarios of the same (or almost the same) magnitude. This possibility could be described as the repetition of MDPs, or if the values of performance are lower than an MDP, as the repetition of very high demanding passages (VHDPs) and high demanding passages (HDPs). Considering futsal as an intermittent sport in which the combination of high-intensity actions and low-intensity short pauses exposes players to a major amount of high physiological, mechanical and locomotor stress (Dogramaci et al., 2011), the identification and comprehension of the repeatability of VHDPs and HDPs may be of great assistance to sports scientists, strength and conditioning coaches and other technical staff members to have a better understanding of the demands of the competition and therefore to better adjust training loads in a quantitative and qualitative perspective (Sánchez-Ballesta et al., 2019).

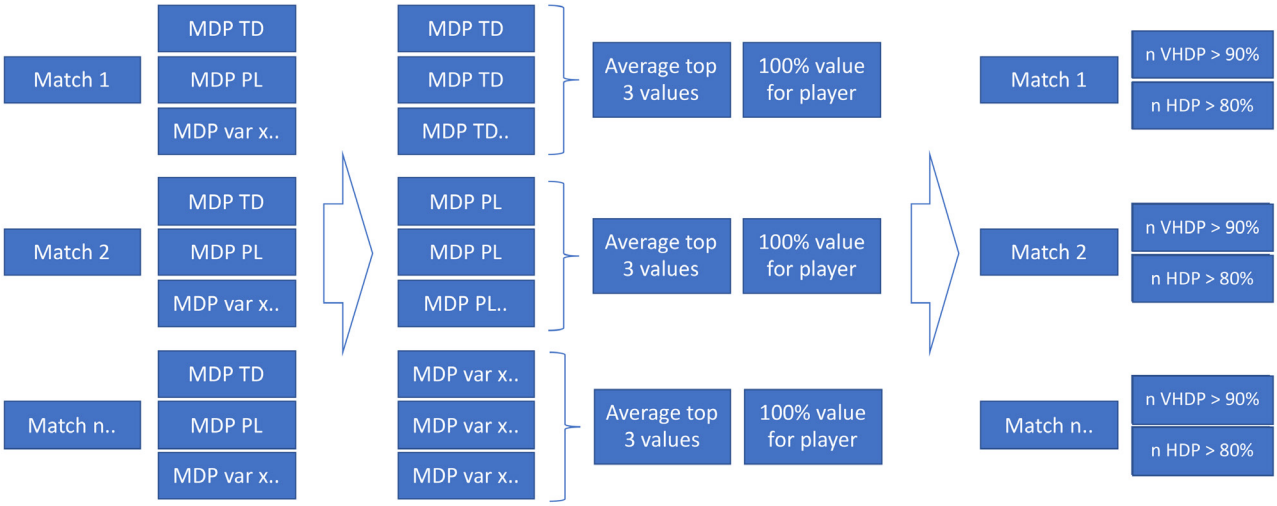
Thus, the objectives of this study were (1) to describe the concept of repetition of VHDPs and HDPs in games by defining the concept of VHDPs and HDPs and (2) to identify how many of these scenarios were present in official games for an elite professional futsal player.

Method

A retrospective observational study was conducted during the 2018-2019 season. Data were collected from one professional futsal player (age: 26 years, weight: 67.5 kg, height: 171.3 cm) from Futbol Club Barcelona with the ultra-wideband (UWB) local positioning system (WIMU PRO™, RealTrack Systems S.L., Almería) from 12 official matches of the Liga Nacional de Futbol Sala (LNFS) 1st Division. The data analysed stemmed from daily player monitoring, in which player activities are measured routinely in the course of the season. Therefore, the approval of an ethics committee was not required (Lacome et al., 2018), although the study was conducted in accordance with the Declaration of Helsinki, and the player provided his informed consent before participating. The logging device was located in the upper part of the back on a tight-fitting vest. The data collected were analysed with computer software (SPRO, RealTrack Systems S.L., version 946) and computed by the data computation software RStudio version 1.2.5033 (RStudio, Inc.) for Windows version 10 Pro. The WIMU PRO™ sensors are equipped with three different inertial sensors: accelerometer, gyroscope and magnetometer, a GPS (10 Hz sample frequency) and a UWB (18 Hz sample frequency). The WIMU PRO™ presented both good/acceptable accuracy and inter- and intra-unit reliability for UWB positioning (Bastida-Castillo et al., 2019).

The rolling average method was used for all variables to determine the MDP of each game. The maximal values for a one-minute time window were calculated and presented for each variable: total distance covered (TD; m·min-1), distance covered at high-speed running (HSR; >18km·h-1; m·min-1), metres covered above 0.02 Player Load (vector magnitude expressed as the square root of the sum of the squared instantaneous rates of change in acceleration in each one of the 3 planes divided by 100 in arbitrary units) (PL; m·min-1), the number of high-intensity accelerations (ACC; >2 m·s-²; n·min-1) and the number of high-intensity decelerations (DEC; >2 m·s-²; n·min-1). Once the MDP of each variable and each game had been determined, the average of the three highest values for each variable was calculated to determine the player's 100%; and the definition of the very high demanding passage (VHDP) threshold (>90% of the mean of the three top MDP) and the high demanding passage (HDP) threshold (80%-90% of

Figure 1
Schematic representation of data processing in 3 steps: firstly, determination of the MDP of each game; secondly, determination of the 100% of each variable for the player; finally, re-analysis of the matches to identify the number of the VHDPs and HDPs above the thresholds.



Note. var = variable

the mean of the three top MDP) was established. Finally, a new computing process was conducted to identify all the VHDPs and HDPs for a one-minute time window in each game for each variable (figure 1).

The results were expressed as the mean number of VHDPs and HDPs occurring for each variable plus the standard deviation (mean ± SD), and the range (minimum and maximum) of number of scenarios per match observed. No other statistical test was conducted because this was a one-player case study and there were no differences to evaluate.

Results

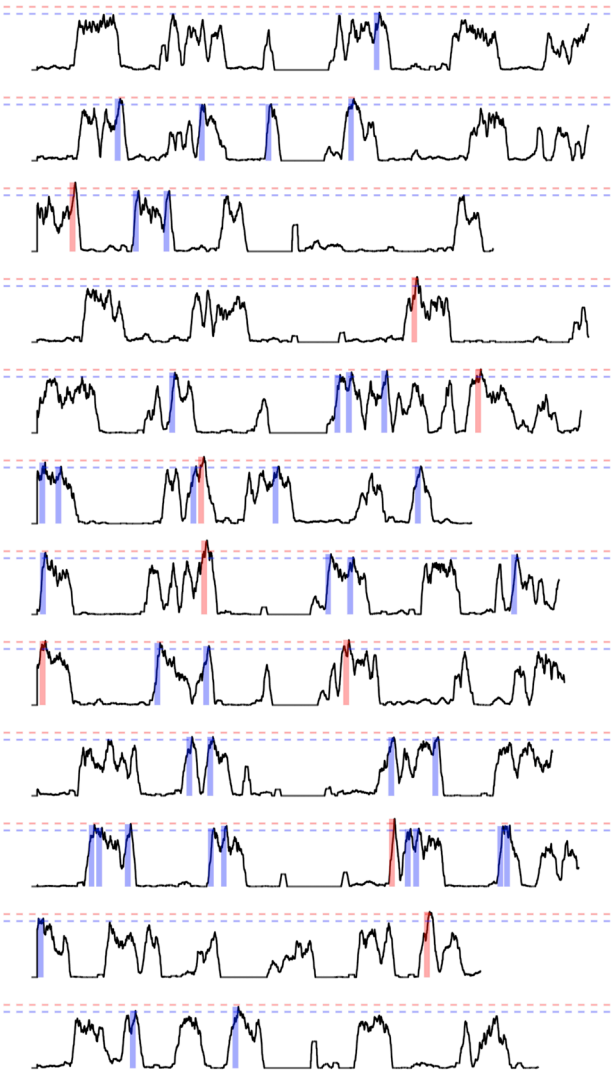
Table 1 displays all the mean values and the SD of the number of VHDPs and HDPs for each variable per game. The results showed that TD was the variable with the greatest number of VHDPs and HDPs in a competitive match; and the range values of the variables showed that there might not be any VHDP or HDP in a match or that there might be several VHDPs and HDPs. Figure 2 shows the stochastic distribution among games suggested by the results of table 1, with games without any scenario and with games with several scenarios.

Table 1
Mean ± SD and range of the number of HDPs and VHDPs for each variable per match.

	Descriptive statistic	TD	HSR	PL	ACC	DEC
Number HDPs per match	Mean ± SD	3.17 ± 2.32	0.17 ± 0	1.17 ± 1.51	2 ± 1.12	0.83 ± 0.53
	Range (min – max)	0 – 9	0 – 1	0 – 5	0 – 5	0 – 2
Number VHDPs per match	Mean ± SD	0.75 ± 0.35	0.17 ± 0	0.17 ± 0	0.67 ± 0.55	0.5 ± 0.58
	Range (min – max)	0 – 2	0 – 1	0 – 1	0 – 2	0 – 2

Note. TD = total distance (m·min-1); HSR = high-speed running (m >18 km·h-1, m·min-1); PL = distance above 0.02PL (m·min-1); ACC = accelerations (>2 m·s-2, n·min-1); DEC = decelerations (<-2 m·s-2, n·min-1).

Figure 2
Sample of 12 games of the player analysed. Moving average of the TD variable in black. Blue rectangles, the HDPs. Red rectangles, the VHDPs. Blue dotted line, the 80% threshold of the mean of the three top MDPs. Red dotted line, the 90% threshold of the mean of the three top MDPs.



Conclusions

The main purpose of this research was to examine not only the MDPs of elite futsal official matches but also to analyse the possible repeatability of similar scenarios (VHDPs and HDPs) and to quantify how many times a player is exposed to them in a single match. The main findings were: (1) the VHDPs and HDPs of a single match did not present as an isolated situation and there was a high variation of each variable between matches; (2) considering match MDPs could help to understand the concept of repeatability of VHDPs and HDPs and (3) TD and ACC were the most repeated HDPs and MDPs of all the variables analysed in a single match.

To our knowledge, this is the first research to address the concept of the repetition of MDPs, the concept of the repetition of MDPs and the concept of establishing thresholds to separate VHDPs from HDPs. It is important to point out that this last concept could constitute a limitation of our research, since the lack of previous research led us to establish an 80% threshold for HDPs and a 90% threshold for VHDPs on the strength of our experience.

The findings of this research point the way for future research analysing the repeatability of VHDPs and HDPs in a match for different professional futsal players and to analyse whether these scenarios present during their training sessions. This may help coaches and strength and conditioning coaches to design, adjust and modify training drills to optimise performance to meet the high demands of competition.

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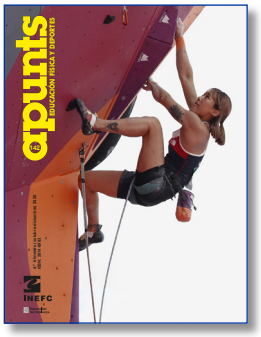

OPEN ACCESS

Methodology for evaluating physical condition in primary school pupils

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Date read: 5 December 2017

Abstract

This study proposes a methodology to evaluate physical condition in primary school adapted to the unique features of schoolchildren and their setting. The need to transform the evaluation process is grounded on different points of view: philosophical, psychological, pedagogical and metrological.

Through the use of investigative research techniques, the criteria of several authors regarding the content and form of evaluating physical condition were integrated, enabling an operational definition to be systematised. This, in turn, yielded the principles of the methodology and the value scales, based on percentages, which enrich the metrological aspects in the general theory of physical education.

The conditional and coordinative capacities and motor skills (basic and sport) studied in physical education programmes for these ages are thus evaluated in a single test. The personalisation of the evaluation process is achieved through two fundamental elements:

- The use of a test which each teacher can adjust to the particularities of their school and setting.
- Each schoolchild can compare their own results based on an initial diagnosis and on the evaluation of four indicators which determine their level of physical condition.

The results are assessed quantitatively and qualitatively by means of the criterion formulated by the experts, the measurements taken and the users' level of satisfaction. For this purpose, different statistical tests were used, such as Kendall's coefficient of concordance, Kendall's Tau-b test, the Wilcoxon signed-rank test and the Ladov technique. They demonstrated that the application of the proposed methodology is feasible.

The main achievements include the fairness, affordability and humanism of this form of evaluating physical condition. Furthermore, the statistical processing program used offers a possible content distribution which enables insufficiencies to be acted on. The conclusions and recommendations include the feasibility of the proposal and the need to continue to investigate the aspects not addressed in depth in order to find new solutions to the problem under consideration.

Keywords: physical condition, evaluation, physical capacities, motor skills, tests.

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New Olimpic Sports for Tokyo 2020. Climbing. Photo: Climbing. Asian Games 2018. Women's combined final. Competes Kim Ja-in from South Korea. Climbing leader. JSC Sport Climbing. Palembang, Indonesia. REUTERS / Edgar Su.

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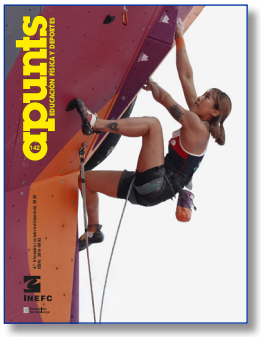

OPEN ACCESS

Analysis of Supply and Demand in Adventure Physical Activities in Nature Tourism. Case Study of L'Alt Empordà

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Director
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Professor at the INEFC and professor of theory and basic manifestations of motor skills

Date read: 7 February 2018

Abstract

Adventure physical activities in nature (APAN) are currently one of the most in-demand forms of tourism in terms of the objectives of and reasons for tourist trips, generating a reality that must be addressed by the destination regions. This study sets out to analyse this phenomenon, framed within the logic of post-Fordist tourism with a consolidated demand in recent years in the region of L'Alt Empordà, and to shed light on its reality and complexity in terms of regional development. The study's overarching objective is to analyse the adventure physical activities in nature practices in tourism in L'Alt Empordà and its regional development in order to lay the groundwork for a new comprehensive and sustainable tourism model of APAN practices. The results point to a heterogeneous demand met by the APAN practices implemented by the companies in this region, thereby confirming, from the standpoint of supply, organisational and structural insufficiency in the development of a comprehensive policy and strategy by all the regional stakeholders. Thus, through the proposal of the case study, providing the foundations needed to build a new comprehensive and sustainable tourism model of APAN practices through strategic and participative planning is deemed timely and important.

Keywords: active tourism, adventure physical activities in nature (APAN), supply, demand, management, regional development.

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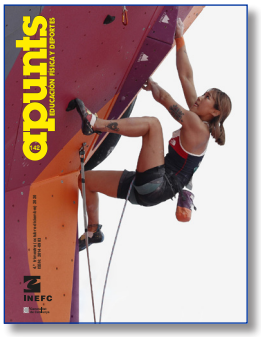

OPEN ACCESS

Diagnostic Evaluation of the Declarative-conceptual Knowledge of Physical Education in Second-year Secondary Education Students in the Province of Llanquihue (Chile)

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Abstract

This study focuses on interpreting the declarative-conceptual knowledge of physical education and its relationship with the meanings attributed to it by teachers in holistic education in the subject in second-year secondary schooling in the province of Llanquihue, Los Lagos Region (Chile). A study with a mixed-method design was conducted with quantitative-qualitative sequential equality of status. The strategy used was to complement and triangulate the data. A total of 659 students between the ages of 15 and 18 years participated, 54% males and 46% females. The study included participants from all the different kinds of schools in Chile, including municipal (36.4%), subsidised (37.8%) and private (25.8%). The sample of teachers was intentional and was comprised of ten teachers, each one representing a school where the survey was administered. Three teachers from subsidised schools, 3 from municipal schools and 4 from private schools participated. Using the quantitative method, the students responded to the Declarative-Conceptual Learning in Physical Education Questionnaire (CADCEF), developed and validated in the Chilean school population. Secondly, using the qualitative method, the teachers expressed the meanings they attribute to declarative-conceptual content in the holistic education of students via an interview. The most relevant results and conclusions reveal a clear weakness in the conceptual dimension of knowledge in the different kinds of schools, associated with a lack of conceptual training and a lack of transfer from theory to practice in their training processes. Using the quantitative method, only 163 students (24.7%) managed to answer more than half of the questionnaire correctly (50% correct responses). In the private schools, 12.1% managed to do so, compared to 8.0% and 4.6% in the subsidised and municipal schools, respectively. Furthermore, no significant differences were found at any kind of school according to the students' sex, although private schools returned the best results. According to the age variable, the 16-year-old students proved to have the greatest cultural baggage in physical education. On the basis of the value assigned to declarative-conceptual contents by the teachers, the latter acknowledge major benefits and teaching strategies through training in declarative-conceptual contents; however, pre-service and teacher training are weak in conceptual contents and they therefore continue to apply traditional methodologies focused on learning how to do it. This hegemonic conception of the discipline as a motor activity is probably conditioned by public policies and by the epistemic essence of physical education.

Keywords: declarative-conceptual knowledge, students, physical education, teachers.

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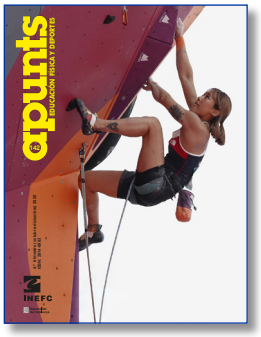

OPEN ACCESS

Children's Sport as an Activity for the Development of Resilience and the Culture of Peace: Children's Sport for Peace

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Date read: 5 April 2018

Abstract

The overarching objective of this thesis was to study the relationship between children's sport, resilience and the culture of peace to lay the groundwork for the values underpinning children's sport as a model of education for peace and consequently the conceptualisation of children's sport for peace.

A systematic literature review was undertaken to identify, evaluate and integrate different studies on the research topic with a view to answering the objectives and hypotheses.

This provided the foundations for the model of children's sport for peace, based on sportspersonship (fair play), the educational values of peace (culture of and education for peace), the cornerstones of child resilience and nonviolent communication in all its educational and athletic dimensions.

Children's sport was reconceptualised as an activity that promotes competition as a learning value, unlike the demands to win in sport, which is virtually comparable to child labour.

One important contribution was the transposition of Children's Rights created by Korczak (1929) into the field of children's sport, most of which coincide with the rights of children who practise sport as postulated in the Children's Rights in Sports Principles (United Nations, 1988), which involved a review and theoretical development from the historical creation of the current rights of children who practise sport.

The main conclusions of the thesis are that children's sport fosters the development of their resilience through their continuously learning how to find alternative ways to overcome the adversities that arise in sports competition. Similarly, resilient children are capable of asserting their own rights as children, their right to play and the rights that protect people who do sport in the face of adult coercion which focuses on triumphalism as the only outcome of competition.

Finally, the practice of sport by children was seen to be a suitable way of fostering education in the culture of peace, education for peace, and ultimately the construction of the values of sport for peace.

In short, children's sport, children's resilience, the culture of peace and education for peace are an ensemble of concepts that promote the values of peace, offering a new conceptualisation represented by children's sport for peace.

Keywords: children's sport, resilience, culture of peace, children's sport for peace.

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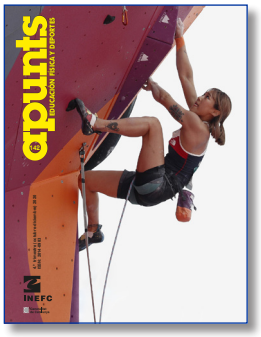

OPEN ACCESS

Physical-therapeutic Exercise in Adolescent Patients with Joint Hypermobility Syndrome

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Date read: 26 June 2017

Abstract

Heritable connective tissue disorders have kindled the interest of genetic sciences and physical culture professionals. Joint hypermobility syndrome (JHS) and the Ehlers-Danlos syndrome, hypermobility type (EDS-HT), are characterised by an excessive range of motion in the joints, arthralgia, myalgia and deformities of the musculoskeletal system, rendering it impossible for sufferers to perform well in daily and school activities. The author's overarching objective is to design a physiotherapeutic exercise programme to relieve musculoskeletal system (MSS) pain in adolescents with JHS and EDS-HT. The programme proposes exercises, doses, adapted load indicators and methodological, control and evaluation guidelines to assist in the planning of the affected persons' physical rehabilitation. The diagnostic includes a survey of 21 experts. A pre-experimental minimal-control descriptive and holistic study for a single group was conducted with a pre-test and post-test in a sample of 20 patients. The subjects attended the Physical Activity and Health Centre of the UCCFD Manuel Fajardo, where they were given initial, intermediate and end-of-programme evaluations. The adolescents who received the programme presented adaptive responses, as evinced in morphology and in improvements in all the indicators evaluated; their MSS pain was relieved and their performance in everyday and school activities improved. The experts rated the physiotherapeutic exercise programme as highly adequate, with a substantial expected effectiveness, and considered it to be novel, effective and useful for society.

Keywords: physical-therapeutic exercise, joint hypermobility syndrome, Ehlers-Danlos syndrome, hypermobility type.

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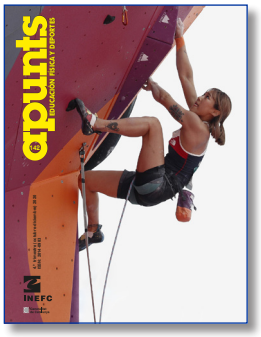

OPEN ACCESS

Care for the Physical Condition of the Elderly who are not Members of the Círculo de Abuelos (Cuba)

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Abstract

The provision of care to the elderly is an extraordinarily important problem, both internationally and in the conditions prevailing in Cuba. Many elderly persons engage in physical activity independently, in most cases with empirical knowledge, lacking a proper personalisation which would meet their organic and psychological needs, and without a regulation that would foster the adaptative processes that inevitably occur in this stage of life. Care for the physical condition of the elderly through sports centres and Health areas has failed to venture beyond the traditional and fundamentally institutional approach, thus foregoing a holistic approach which entails the practice of physical activity independently.

Theoretical and empirical methods were used to conduct this study. Basic and descriptive statistics were employed to organise and characterise the data recorded in the study. Hypothetical tests for related samples were applied for data comparison, the Wilcoxon test, and the Mann-Whitney test was used to compare two independent samples.

The study was conducted in the municipality of Las Tunas (Cuba). An intentionally selected sample of 1,015 elderly persons, 100 family physicians and 52 community physical activity teachers was used to ascertain how physical condition behaved.

The diagnosis allowed us to identify the needs evinced in care for the physical condition of the elderly, which helped to distinguish the differences between the members and non-members of the Círculos de Abuelos.

A three-tier intervention strategy was designed: institutional, community and individual, with actions geared towards the provision of care for the physical condition of the elderly, focusing on non-members of the Círculos de Abuelos. A major effort was made in terms of educational intervention, which proved to be decisive in achieving a transformation in the types of motor care.

The particular principles that underpin the strategy emerged from the theoretical foundations defined in the research: coordinated and systematic communication, awareness-raising and the sustainable nature of the actions.

The design of the intervention proposal to improve the care provided for the physical condition of the elderly does not only include their needs, it also considers the professional performance of the experts entrusted with applying it and of those who implement and monitor it, identified in the aforementioned three tiers.

The behaviour of the physical condition of non-members of Círculos de Abuelos presented results closer to those of their peers who were members.

Keywords: the elderly, care, physical condition.

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