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APPLICATION OF RESISTANCE TRAINING PRACTICES OF ELITE SPANISH ROLLER HOCKEY TEAMS

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ABSTRACT

The results of a survey on resistance training in a professional roller hockey league and an amateur league were compared. The response rate was 93.3% (28 of 30). The profile of the physical trainer, overload exercises, intensity of resistance training, speed of execution of repetitions and training until muscular failure was examined. The results indicated that 60% of the physical conditioning coaches had a university degree, 32.5% had a master's degree and only 10% consulted scientific journals. In some cases, the respondents relied on unscientific sources to develop their conditioning programmes. Many trainers did not use Olympic exercises (50%), full squats (50%) or bench press throws (40%). Most interviewees controlled the intensity of the load, although some of the equipment did not use a recommended intensity of 50-90% of 1RM because the trainers did not use them currently. For these load intensities, the majority performed a combination of maximum speed in the repetitions and did not reach muscle failure. The most significant deficiencies in the fundamental principles of resistance training were observed in the amateur league. The profile of the trainers of Spanish teams are inadequate for optimal applications. Spanish trainers should take advantage of scientific research findings.

***Keywords*:** Roller Hockey; Physical conditioning coaches; Resistance exercises; Resistance load; Repetition velocity; Muscular failure; Survey.

INTRODUCTION

Roller hockey is one of the most popular sports in Catalonia (Spain) and one of the most successful sports in all of Spain. Currently, Spain occupies the first place in the Men's World Hockey Championships, having won a total of seventeen times. Given that physical conditioning is known to be important for the success of team sports (Reverter-Masia *et al*., 2009), it is not surprising that many articles have described the components of some conditioning programmes in these sports (Gambe, 2006; Marques & González-Badillo, 2006; Marques *et al*., 2006; Legaz-Arrese *et al*., 2007; Johnston *et al*., 2015; Rivière *et al*., 2017) or have scientifically evaluated several of its aspects (Gorostiaga *et al*., 1999; Bangsbo *et al*., 2006; Reverter-Masia *et al*., 2008; Schoenfeld *et al*., 2016).

Resistance training has been shown to be effective in the prevention of injuries (Sewry, 2017) and in the improvement of speed in specific motor tasks of collective sports (Marques & González-Badillo, 2006; Reverter-Masia *et al*., 2008; Rivière *et al*., 2017). To enhance

performance, an optimal combination of the load (Kawamori & Haff, 2004; Kraemer & Ratamess, 2004, Sarabia *et al*., 2017), exercises (Kawamori & Haff, 2004; Kraemer & Ratamess, 2004; McMaster *et al*., 2013), speed of the repetitions (Izquierdo *et al*., 2006a; Lawton *et al*., 2006; Schoenfeld *et al*., 2015) and the number of repetitions (Folland *et al*, 2002; Izquierdo *et al*., 2006a; Schoenfeld *et al*., 2015) are required. In team sports, and in agreement with Marques *et al*. (2006), a minimum interval of 50-90% of 1RM is required to develop strength and power. In relation to this, multi-articular, Olympic and ballistic exercises appear to be more appropriate to increase sports performance (Kraemer & Ratamess, 2004).

Exercises to improve the strength of non-dominant muscles and antagonists are required for injury prevention (Noffal, 2003). For sports that demand explosive force (in the case of roller hockey), athletes should try to execute the exercises in an 'explosive' manner at the maximum possible speed for the resistance used (Muun *et al*., 2005; Izquierdo *et al*., 2006b). Thus, some authors have suggested that there is a potential beneficial stimulus obtained from training with overloads when the series are not executed until muscle failure (Izquierdo *et al*., 2006b). Some of these scientific principles of resistance training have been included in the current guidelines of team sports training programmes (Murlasits, 2002; Gambe, 2006; Marques & González-Badillo, 2006; Marques *et al*., 2006; Legaz-Arrese *et al*., 2007; McMaster *et al*., 2013; Rivière *et al*., 2017).

Considering the currently accepted importance of physical conditioning, many teams hire physical trainers to help prepare athletes for maximum performance and to prevent injuries (Pullo, 1992; Sutherland & Wiley, 1997; O'Brien & Finch, 2017; Rodríguez *et al*., 2018).

Different studies have highlighted the importance of the profile of the physical trainer to apply strength and conditioning programmes that are scientifically credible (Laskowski & Ebben, 2016). The basic requirement for a physical trainer is to be a graduate in physical activity and sports sciences. In addition, specific training in sports and strength and conditioning programmes, as well as previous experience as a physical trainer, increase the likelihood of developing a more specific training regime (Gillham *et al*., 2017). As in all fields of knowledge, the continuous scientific training obtained through courses, graduate degrees, and consultation of specialised journals, is essential in order to ensure that physical conditioning programmes are based on the practical application of scientific knowledge (Krkeljas *et al*., 2017).

Surveys are an effective method to determine the profile of physical trainers and the current practices of strength and conditioning methods (Reverter-Masia *et al*., 2009). These practices have been examined as aspects of strength and conditioning programmes, and the profiles of physical trainers in national leagues of various sports have been assessed, including baseball (Sutherland & Wiley, 1997; Ebben *et al*., 2005), football (Ebben & Blackard, 2001) basketball (Simenz *et al*., 2005), ice hockey (Ebben *et al*., 2004), and soccer (Reverter-Masia *et al*., 2009). However, a survey and analysis of roller hockey teams has not been employed.

PURPOSE OF STUDY

The purpose of this study was to explore how much scientific research influences resistance training practices in the Spanish top-level elite leagues, such as OK Liga and First Division. This study also determined if teams with physical trainers that have a more specific training and a higher education level execute better conditioning programmers based on scientific knowledge.

METHODOLOGY

Coaches

To accomplish the proposed objectives, physical conditioning coaches (PCCs) of the male teams that participated in the Spanish roller hockey league during the 2014/15 season, namely OK Liga (n=14, elite teams) and First Division (n=16) (League of the Roller Hockey Clubs Association) were invited to be interviewed. There are two maximum roller hockey categories. The PCCs showed that there were no significant differences between the training of new and expert players within the same team during competitive seasons (individualised training takes place during the non-competitive season).

Survey

The survey questionnaire was created with the help of experts in questionnaire design and was pilot-tested with an informal advisory group of physical conditioning coaches. The five areas of inquiry were: (a) PCC profile; (b) resistance training exercises; (c) resistance training load; (d) repetition velocity; (e) training leading to failure; and (f) usage of an encoder to measure the exercise with free weights and the bar displacement over time. Finally, the type of season was not considered because, as different authors have stated (Nunes *et al.*, 2018; Wing, 2018), the competitive schedule is not constant. Therefore, the PCC should be flexible and able to easily adjust programming to the changing competitive schedule. The PCC must be aware that it is very unlikely that there is a 'textbook' periodisation strategy in collective sports and that very often the strategy that must be applied is the 'best fit'. A non-linear-based approach appears to accommodate this strategy best (Blagrove, 2014; Wing, 2018).

Ethical clearance

The study was performed following the ethical guidelines of the Declaration of Helsinki 1961 (revision of Fortaleza 2013). The protocol study was approved by the Ethics Committee of the University of Lleida, Spain. The present study was registered as 0313.

Data collection

To contact the physical trainers, a letter describing the project was sent to the official addresses of all the teams. The objectives of the letter were to explain the purpose of the study, the confidentiality of the information and the motivation of the researchers to conduct the survey. After two weeks, a telephone call was made to the official headquarters of the teams in order to talk to each physical trainer personally. Several attempts via telephone, letter and email were made to contact those who could not be located initially.

***Table 1*. RESPONSE RATE: PHYSICAL CONDITIONING COACHES**

Participants	League	
	OK Liga	1st Division
Number of teams (n=30)	14	16
Number of teams interviewed (n=27)	12	15
Total interviewed (Rate = 90%)	85.71%	93.75%

Finally, 28 physical conditioning coaches agreed to participate in the study (Table 1). Two physical trainers declined to participate or did not respond to emails, letters or telephone calls. A date was agreed with each physical trainer to administer the questionnaire as a personal interview.

The data collection and analysis were performed by a member of the research team while the other worked as an assistant. The team members approved the transcript of the interviews, which lasted 90 minutes. The interviews were recorded using video and audio, which was later transcribed by two external professionals. The accuracy of the transcripts was verified by the interviewers. The images of the exercises were shown to the PCC interviewees for better understanding (Figure 1).

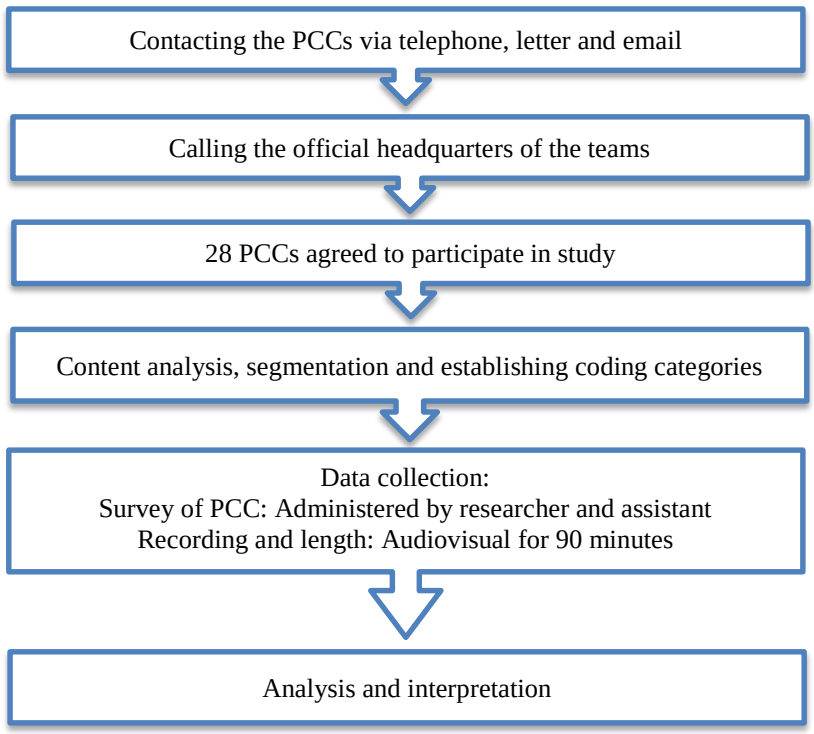

Figure 1. **STUDY DESIGN**

Statistical analysis

The statistical analysis was performed with the Statistical Package for Social Sciences, Version 24.0 software. Data were expressed in percentages. Chi-squared or Fisher and Mann-Whitney U tests were applied for qualitative and quantitative ordinal variables, respectively, in order to determine differences among the leagues. The p-level was set at 0.05.

RESULTS

PCC profile

Regarding the profile of physical conditioning coaches, differences were found among categories: 80% of the physical conditioning coaches of OK Liga have degrees in physical activity and sport sciences, in contrast to 40% of the physical conditioning coaches of the First Division ($p<0.001$). Respectively, 45% and 20% of the physical conditioning coaches had a master's and doctoral degree in related fields of human performance. A high percentage of physical conditioning coaches declared they have attended at least one course of more than 20 hours in the last three years (80%) and know the physical preparation developed by at least one team in his league (90%). Although the majority of physical conditioning coaches consult specific journals related to their professional activity (75%), only 10% consult journals included in the Science Citation Index (JCR). There were also no differences in the time that elapsed since graduation of the physical trainers (9.2±6.3 years) nor in the experience as a physical trainer in national leagues (5.5±6.1 years).

Resistance training exercises

All teams declared using overload exercises to improve training.

Table 2. **CHEST, SHOULDERS AND TRICEPS EXERCISES USED BY PCC: EXTENSORS OF UPPER EXTREMITIES**

Exercises	**OK Liga** (n=12)		**1st Division** (n=15)	
	No. teams	%	No. teams	%
Flat and vertical machine bench press	9	75.0	4	26.6
Flat and incline barbell bench press	3	25.0	1	6.6
Flat and incline dumbbell bench press	9	75.0	9	60.0
Machine shoulder press	7	58.3	4	26.6
Seated barbell shoulder press	3	25.0	0	0.0
Seated dumbbell shoulder press	3	25.0	2	13.3
Triceps pushdown	9	75.0	8	53.3
Lying barbell triceps extension	4	33.3	4	26.6
Dumbbell triceps kickback	5	41.6	4	26.6

Data are expressed in percentages

As seen in Table 2, a greater percentage of OK Liga teams worked flat and vertical machine bench presses and flat and incline dumbbell bench presses. In the First Division, the most used exercise was the flat and incline dumbbell bench press, and flat and incline barbell bench press. Significant differences were found ($p<0.05$) between the OK Liga teams compared to that of the first division teams in all the exercises of extensors of the upper extremities.

More than 75% of the OK Liga teams used triceps pushdown exercises, 50% used a machine shoulder press and only 25% of the equipment, namely seated barbell shoulder press, seated dumbbell shoulder press and lying barbell triceps extension, and less than 50% used the dumbbell triceps kickback. The First division more frequently used flat and incline dumbbell bench presses and triceps pushdown and less frequently used lying barbell triceps extension, dumbbell triceps kickback, a machine shoulder press and flat and vertical machine bench press. Differences were found with respect to the OK Liga ($p<0.05$).

Flexors of the upper extremities: Back and biceps exercises

Upper extremity flexor exercise was used by more than 75% of the teams. However, significant differences were observed in the majority of teams of the OK Liga compared to that of the First Division in the performance of flexor exercises ($p<0.05$).

Forearm and finger exercises

A low percentage of the teams performed forearm and finger exercises. The OK Liga team used barbell curl and extension wrist (15%), dumbbell curl and extension wrist (12%), and curl and extension fingers (3%).

Abdominal exercises

All the PCCs indicated that they exercised the abdomen, including bent-knee sit-ups and crunch exercises.

Lower extremities: Hip, thigh and calf exercises

As seen in Table 3, the OK Liga teams differed significantly in the use of snatch compared to that of the First Division teams ($p<0.05$). In the two leagues, 60% of the teams worked split with bar and machine leg extension. The percentage of OK Liga teams that performed exercises with machines was high. However, the exercises with machines were scarcely used by trainers of the First Division, showing significant differences between the two leagues ($p<0.001$). Calf exercises were carried out by the OK Liga teams and by half of the First Division teams. With the exception of the OK Liga teams, the physical trainers did not use exercises of seated hip adduction-abduction and leg curls ($p<0.05$).

Power exercises

In the OK Liga teams, the snatch was made by most teams (>50%). The snatch exercises were performed by a minority of the First Division teams.

Ballistic exercises

Very few of the OK Liga teams and First Division used the bench press throw exercise.

Other exercises

A total of eight extra exercises were indicated by at least one physical trainer. Only three exercises were scored by more than 20% of the physical trainers: dumbbell pullover (17%), bent-arm barbell pullover (20%) and the flat and inclined dumbbell fly (18%).

Table 3. **LOWER EXTREMITIES: HIP, THIGH, CALF EXERCISES USED BY PCC**

Exercises	**OK Liga** (n=12)		**1st Division** (n=15)	
	No. teams	%	No. teams	%
Snatch	6	50.0	6	40.0
Clean	5	41.6	5	33.3
Variants: Snatch y/o Clean (push press, push jerk)	0	–	0	–
Barbell squat	7	58.3	4	26.6
Bench press	0	0.0	0	0.0
Split with bar	7	58.3	9	60.0
Machine squat	2	16.6	5	33.3
Machine leg extension	7	58.3	9	60.0
Leg curl leg flex in machine	7	58.3	5	33.3
Machine standing and seated calf raise	7	58.3	4	26.6
Barbell calf raise	2	16.6	1	6.6
Seated hip adduction-abduction	0	–	1	6.6
Bench press throw exercise	2	16.6	4	26.6

Data are expressed in percentages

Overview analysis of most used exercises

In summary, the exercises that were implemented by more than 50% of the physical trainers are shown in Table 4. Data are expressed in percentages.

Intervals of load intensity

Table 5 shows the percentage of physical trainers who indicated they work at different intensity intervals. Only 10.4% of the physical trainers worked with a load <30% of 1RM. The number of teams that worked in the range of 30-50% of 1RM was also low. Numerous physical trainers (47.9%) reported working at 50-70% of 1RM, establishing significant differences between leagues ($p<0.001$). The 70-90% interval of 1RM was used the most. This interval was used by the majority of OK Liga teams (66.6%) compared to 43.7% of the First Division ($p<0.01$). The equipment of First Division was used with intensities of 90-100% of 1RM to a greater extent.

Optimal training load

Ten teams did not work with different load intensity intervals. The majority of OK Liga teams used different intervals, and only seven First Division teams ($p<0.001$) did so. In addition, more than half of the First Division teams did not work with the minimum recommended interval load, which was 50-90% of 1RM.

Repetition velocity

Four teams worked with an intensity <30% of 1RM and their physical trainers indicated to not execute intensity at the maximum speed of execution. For an intensity of 90-100% of 1RM, all the teams executed repetitions at the maximum speed. A greater percentage of the OK Liga teams, in relation to the First Division teams, executed the repetitions to the maximum speed,

that is, to an intensity of 50-70% and 70-90%. Many teams also worked at non-maximum speeds at intensities of 50-70% and 70-90%.

Usage of the encoder

Unlike the First Division, most of the OK Liga teams used the encoder (12.5% vs. 57.1%, respectively).

Table 4. **MOST USED EXERCISES FOR EACH CATEGORY BY PCC**

#	**OK Liga** (n=12) Exercise	%	**1st Division** (n=15) Exercise	%
1.	Flat/vertical machine bench press	75.0	Flat/incline dumbbell bench press	60.0
2.	Flat/incline dumbbell bench press	75.0	Split with bar	60.0
3.	Triceps pushdown	75.0	Machine leg extension	60.0
4.	Machine shoulder press	58.3	Triceps pushdown	53.3
5.	Barbell squat	58.3	Snatch	40.0
6.	Split with bar	58.3	Clean	33.3
7.	Machine leg extension	58.3	Machine squat	33.3
8.	Leg curl leg flex in machine	58.3	Leg curl leg flex in machine	33.3
9.	Machine standing/seated calf raise	58.3	Flat/vertical machine bench press	26.6
10.	Snatch	50.0	Machine shoulder press	26.6
11.	Dumbbell triceps kickback	41.6	Lying barbell triceps extension	26.6
12.	Clean	41.6	Dumbbell triceps kickback	26.6
13.	Lying barbell triceps extension	33.3	Barbell squat	26.6
14.	Flat/incline barbell bench press	25.0	Machine standing/seated calf raise	26.6
15.	Seated barbell shoulder press	25.0	Bench press throw exercise	26.6
16.	Seated dumbbell shoulder press	25.0	Seated dumbbell shoulder press	13.3
17.	Machine squat	16.6	Flat/incline barbell bench press	6.6
18.	Barbell calf raise	16.6	Barbell calf raise	6.6
19.	Bench press throw exercise	16.6		
20.	Barbell calf raise	40.0		

Table 5. **INTERVAL LOAD INTENSITY BY CATEGORY USED BY PCC**

Intensity	**OK Liga** (n=12)	**1st Division** (n=16)
Less 30% of 1RM	8.30	12.50
30-50% of 1RM	25.00	25.00
50-70% of 1RM	58.30	37.50
70-90% of 1RM	66.60	43.75
90+% of 1RM	33.30	43.70

Data are expressed in percentages

Training leading to muscle failure

No physical trainer performed training until muscle failure at the 1RM intensity (Table 6).

Table 6. **COMBINATION OF RUNNING SPEED AND MUSCLE FAILURE FOR EACH LOAD INTENSITY INTERVAL USED BY PCC**

Intensity	**Max. speed & non-failure**		**Max. speed & failure**		**No max. speed & non-failure**		**No max. speed & failure**	
	OK	1st Div	OK	1st Div	OK	1st Div	OK	1st Div
< 30% of 1RM (n=3)	0	0	0	0	33.3	66.7	0	0
30+-50% of 1RM (n=8)	0	0	0	0	50.0	50.0	0	0
50+-70% of 1RM (n=27)	58.3	41.7	0	0	33.3	41.7	0	0
70+-90% of 1RM (n=26)	58.3	46.2	0	0	30.8	69.2	0	0
90+-100% of 1RM (n=19)	0	0	0	0	40.7	59.3	0	0

Data are expressed in percentages

DISCUSSION

This study was the first that determined the most relevant aspects of resistance training in roller hockey in one of the most powerful leagues in the world. The results showed that the profile of the physical conditioning coaches is associated with the level of professionalism of the teams. Thus, most of the teams in the OK Liga have hired a physical trainer with a degree in physical activity and sports sciences exclusively for developing the conditioning of the players. The Spanish Roller Hockey OK Liga is recognised as professional. The best teams are considered professional. They hire the best players in the world and compete successfully in European and world competitions.

In contrast, a high percentage (60%) of the First Division trainers do not have a degree in physical activity and sport sciences, and the conditioning is developed by the head coach. These results suggest that the most professional teams, with higher budgets, seriously consider the strength and conditioning needs of their players and try to prepare them even better for competition.

The fact that during the years following the graduation of the physical trainers (9.2±6.3 years) only a very low percentage continued with more academic education (master's or doctoral degree) or consulted journals included in Science Citation Index is of special interest. The percentage of physical trainers with a master's degree was higher than that in similar studies in other Spanish elite leagues, but lower than that of the physical trainers of the American and Canadian professional leagues of baseball, basketball, football and ice hockey during the season 1994-1995 (Sutherland & Wiley, 1997) and less than that among the physical trainers of American university leagues (Durrel *et al*., 2003).

Durrel *et al*. (2003) surveyed the First Division physical trainers and found that 94% of the respondents consulted *Strength and Conditioning Journal*, 34% the *Journal of Medicine and Science in Sport and Exercise* and approximately 10% the *Journal of Strength and Conditioning Research*. Only 10% of Spanish physical trainers consulted journals included in the Science Citation Index. These results are very negative (Lefebvre *et al*., 2016) because it is fundamental in the development of the coach to learn about scientific research and for them to use the information in the field of coaching science.

Based on these findings, there is the possibility that many of the strength and conditioning programmes are based on sources that lack scientific credibility. This fact was corroborated by other authors (Haff, 2010; Hartshorn, 2016; Buchheit, 2017) who confirmed that poor research discredits the physical conditioning coach profession. In fact, important deficiencies were found in several of the components of the resistance training programmes for the physical development of players in the Spanish elite teams that were studied.

The exercises used for physical conditioning were in accordance with those found in other surveys that analysed the exercises used in team sports, which indicated that the variants of the Olympic exercises and squat are the exercises most commonly used by professional players (Ebben *et al*., 2004; Ebben *et al*., 2005; Simenz *et al*., 2005) and university players (Durrel *et al*., 2003; Laskowski, 2016). It was found that the physical trainers of OK Liga mostly used the snatch and/or variants, while the teams of the First Division league used the step-up to a greater extent. Olympic exercises are considered as some of the best exercises to maximise sports performance (Garhammer, 1993; Haff *et al*., 2001; Schoenfeld *et al*., 2015). Squat exercises (complete sittings) are necessary for the prevention of injuries (Poliquin, 1992; Dinc, 2017) and these are only used by half of the OK Liga teams.

A great variety of uni-articular exercises were used by the OK Liga teams, and exercises of machine leg extension were the most used by the physical conditioning coaches. Exercises of machine leg extension may be suitable for strengthening after an injury, but their effectiveness in improving performance is doubtful (Panariello, 1991). The use of many exercises can be excessive in resistance training. In relation to this matter, several studies have established an optimal training volume threshold (Bosco *et al*., 2000; González-Badillo *et al*., 2006; Nunes *et al*., 2018).

A very low percentage of First Division teams used overload exercises in machines that only used machine leg extension. This finding can certainly relate to the lack of infrastructure and time for the prevention of injuries. It can also be attributed to the fact that many First

Division teams do not have a graduate physical trainer or one who knows about the recovery process, which means that this area is neglected.

Very few of the OK Liga and First División teams from the survey used bench press throw exercises and most of the physical trainers did not include the half-squat jump with overloads in their training programmes. It is now known that ballistic techniques in resistance training are useful to improve muscle power and sports performance, because they limit the deceleration phase (Sarabia *et al*., 2017). This result seems to suggest that there are deficiencies in the evaluation and recovery process of the players. Most likely, these results may be related to the fact that many physical conditioning coaches have not received adequate continuous scientific information.

None of the flexor exercises of the upper limbs were used by more than 60% of the teams and their use was very low in the First Division. This exercise may involve an increased risk of injury to the dominant upper extremity (Aaltonen *et al*., 2007).

Most OK Liga teams worked with intensity of 50-90% of 1RM, which was different from the First Division teams. These data revealed an adequate overload strategy in many of the analysed teams. According to the conclusions of numerous studies, this overload intensity is necessary to increase maximal strength and to increase muscle power and dynamic performance (McBride *et al*., 2002; Kawamori & Haff, 2004; Kraemer & Ratamess, 2004; Peterson *et al*., 2005; Rivière *et al*., 2017). It should be noted that these results were much better than other analyses of elite Spanish leagues from other team sports (Reverter-Masia *et al*., 2009), so it is clear that, despite evolving very slowly, it does so properly towards a practice based on scientific knowledge.

In relation to the execution speed of the repetitions and training until muscle failure, in the majority of the teams that were studied, it was not executed at maximum speed or until muscle failure, with a resistance lower than 50-90% of 1RM. Therefore, regarding speed, many of the teams are executing the exercises incorrectly. According to Lawton (2006), McKinnon *et al*., (2017) and Sarabia *et al*. (2017), executing the number of repetitions that can be performed at maximum speed can induce selective hypertrophy of the fast fibres and allow a greater transfer of training effects for improvement of the speed of specific motor tasks.

The results of this study showed how some PCCs from the OK Liga and many from the First Division did not use an encoder. This observation implies that a large percentage of the PCCs do not have scientific data to reorient and individualise strength training, nor do they know the proper load intensity to accomplish the maximum power for each player and exercise.

It is possible that some of the differences between teams of different performance levels will be due to the outcome of many factors, including the culture of strength training that each sport has historically developed, the level of professionalisation, the conditioning services offered by the teams, the time devoted to conditioning, the competition calendar, the coach-athlete ratio, the difficulty of involving players and coaches in the programme, dual responsibilities and the emphasis given to injury prevention rather than the increase in performance.

Finally, there is also a percentage of the teams, mostly from the OK Liga, working at the correct speed and interval that do not work at maximum speed or until muscle failure. This fact is attributed to the exercises for the prevention of injuries (Fort-Vanmeerhaeghe *et al*., 2016), which means they would be doing them correctly. This study showed that there are significant differences between leagues of the same sport in the use of training practices with overloads based on scientific principles.

The overall results of this survey suggest that the resistance training programmes used by many of the teams differ significantly in scientific knowledge (Kawamori & Haff, 2004; Kraemer & Ratamess, 2004; Muun *et al*., 2005; Izquierdo *et al*., 2006b; Lawton *et al*., 2006; Marques & González-Badillo, 2006; Rivière *et al*., 2017) and from the programmes recommended for the physical development of the players of the team sports (Marques & González-Badillo, 2006; Marques *et al*., 2006; Gamble, 2006; Legaz-Arrese *et al*., 2007). These results also differ from comparable data that have been reported previously in surveys with professional (Ebben & Blackard, 2001; Ebben *et al*., 2004; Ebben *et al*., 2005; Simenz *et al*., 2005) and university teams (Durrel *et al*., 2003), as well as other Spanish elite leagues (Reverter-Masia *et al*., 2009).

It is evident that a PCC requires a graduate degree and a postgraduate degree related to physical conditioning, as well as the necessary practices for the PCC to acquire applied knowledge based on scientific evidence. Additionally, the PCC must be aware that it is unlikely that there is a single periodisation strategy in elite hockey and, therefore, that very often the strategy that must be applied is the best fit.

CONCLUSIONS

Physical conditioning coaches have important deficiencies in academic and/or federative development, especially the first division physical conditioning coaches. Continuous scientific education of the physical conditioning coaches is almost non-existent. Most physical conditioning coaches do not apply their academic and scientific knowledge to training programmes. In many cases and particularly the first division teams, the strength training programmes applied in roller hockey did not respect the scientific attributes associated with the exercises, load and intensity. This study showed that there are differences in the scientific application of training between different categories of leagues.

PRACTICAL APPLICATIONS

This study showed important deficiencies in resistance training of elite teams. These results should encourage the physical trainers of these teams to examine their working methods and justify the necessity for them to undertake continuous scientific training. In the same way, this research should serve as feedback between the scientific community and the physical trainers of other teams from different perspectives, namely knowledge of resistance training developed in roller hockey in one of the most powerful leagues in the world; the necessity to resolve numerous questions about optimal training with overloads in this sport; the necessity to improve the strategies of transmission of scientific knowledge to the coaches involved in the development of the players; and as a model to perform similar studies in other countries, sports and institutions, as well as to determine the changes in the equipment analysed in this study.

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