

A PROFILE OF THE RESISTANCE TRAINING PRACTICES OF ELITE SPANISH CLUB TEAMS

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ABSTRACT

Reverter-Masía, J, Legaz-Arrese, A, Munguía-Izquierdo, D, Barbany, JR, Serrano-Ostáriz, E. A profile of the resistance training practices of elite Spanish club teams. *J Strength Cond Res* 23(4): 000–000, 2009—This study describes the results of a survey of the resistance training practices of the following Spanish sports teams: soccer and basketball professional leagues, and top-division leagues for handball, volleyball, indoor soccer, and field hockey. The response rate was 81.8% (77 of 94). This survey examines (a) strength and conditioning (S&C) coach profiles, (b) resistance training exercises, (c) resistance training load, (d) repetition velocity, and (e) training leading to muscle failure. The results indicate that 80.5% of coaches held a university degree, with 22% holding a master's degrees, 40% held National Federation certification, and none held Strength and Conditioning Specialist certification. Respondents relied on nonscientific sources of information to develop their conditioning programs. Fifty-eight percent of the S&C coaches were hired full time, with 18% performing the duties of a first trainer. Many S&C coaches did not use Olympic lifts (54%), full squat (51%), load squat jump (35%), or bench press throw (100%) exercises. Thirty-eight percent of respondents did not control the load intensity or did not use a load of 50–90% of 1 repetition maximum. For these load intensities, 70% did not perform the combination of maximum repetition velocity and nonmuscular failure. More significant deficiencies in the fundamental principles of resistance training were observed in indoor soccer, soccer, field hockey, and among lower performing handball and basketball teams. These results indicate that the profile of the S&C coaches in the Spanish teams is insufficient for an optimal application of resistance training. Spanish S&C coaches should therefore take advan-

tage of advances made through scientific research in the area of strength and conditioning by acquiring master's degrees and specific certificates and consulting peer-reviewer journals.

KEY WORDS strength and conditioning coaches, resistance exercises, resistance load, repetition velocity, muscular failure

INTRODUCTION

Handball, basketball, volleyball, indoor soccer, soccer, and field hockey are the most popular team sports in many parts of the world, including Spain. Given that conditioning is known to be important for success in team sports, it is not surprising that many articles have described the components of such team sports' conditioning programs (3,4,12,24) or have scientifically evaluated various aspects of physical conditioning (1,15,28).

Resistance training has been shown to effectively improve injury prevention (38) and speed in certain team sports skills, such as kicks in soccer (37), throws in handball (3), and specific jumps in volleyball (28). To enhance dynamic athletic performance, the optimal combination of load (19,21), exercises (19,21), repetition velocity (17,22), and repetition count (10,18) is required. In team sports, in agreement with Cardoso-Marques et al. (4), a minimum load of 50–90% of 1 repetition maximum (1RM) is required to develop strength and power. In light of this, multiple-joint, Olympic, and ballistic exercises seem more appropriate to enhance the athletic performance (21). In addition, functional exercises to improve nondominant and antagonist muscle strength are required for injury prevention (30). For sports that require explosive power, athletes should try to perform exercises “explosively” at the maximum velocity allowed by the resistance used (17,27). Thus, some authors suggest that there is a potentially beneficial stimulus to be gained from resistance training that is not performed to the point of failure (18). Such scientific principles of resistance training have been included in the present-day guidelines of training programs for team sports (3,4,12,23,24,26).

In light of the accepted importance of physical conditioning today, many teams hire strength and conditioning (S&C) coaches to help prepare athletes for top performance and

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avoid injuries (34,36). Different studies highlight the importance of the profile of the S&C coaches for the application of strength and conditioning programs based on scientific credibility (5,20,34,36). The basic requirement for an S&C coach is a degree in Physical Activity and Sports Sciences. In addition, specific formation in the sports and in the strength and conditioning programs, as well as previous experience as an S&C coach, would probably favor the development of a more specific type of training. As in all fields of knowledge, continuous scientific formation gained through coursework, Master's degree programs, and consultation of specialized journals, may be considered essential in order to assure that the physical conditioning programs are based on practical application of scientific knowledge.

The strength and conditioning services offered by a club and likely the S&C coach's profile as well are possibly influenced by the club's professional rank. In Spain, only the top-division leagues of soccer and basketball are officially considered professional leagues. Traditionally, the top-division Spanish handball and indoor soccer leagues are considered to be among the better leagues in the world. However, only the better handball teams and certain indoor soccer players and coaches can be considered professionals; the top-division Spanish league volleyball and field hockey teams are not professional.

Surveys are an effective method of determining S&C coach profiles and the active content of contemporary strength and conditioning practices. They have been previously used to examine some aspects of strength and conditioning programs and of the S&C coach profiles in National Leagues for several sports, including baseball (9,36), American football (7,36), basketball (35,36), and ice hockey (8,36). Nevertheless, no one has yet used such surveys to analyze handball, volleyball, indoor soccer, soccer, and field hockey teams. The purpose of this study was to survey the extent to which scientific research influences resistance training practice for the male teams of top-division Spanish leagues for handball, basketball, volleyball, indoor soccer, soccer, and field hockey. In addition, we sought to determine if teams with coaches with more specific training and higher education levels were more likely to use scientifically based conditioning and be better conditioned overall.

METHODS

Experimental Approach to the Problem

A survey was created by the authors to test the extent to which scientific knowledge of fundamental principles of resistance training is applied in elite Spanish team sports clubs. Our hypothesis was that, presently, there are significant differences in the S&C coach profiles between sports and between teams of the same sport, due to the differences in their professional levels, and that these differences determine the team's use of scientifically based resistance training practices.

Subjects

To accomplish the proposed objectives, we interviewed those responsible for the strength and conditioning of male teams that participated during the 2004–05 season in the top-division Spanish league for handball, basketball, volleyball, indoor soccer, soccer, and field hockey.

For each sport, the teams were divided into "class A," which included the teams with greater performance in their respective leagues (50% percentile of the standings), and "class B," which included the remaining teams.

Performance Level of the Teams

Given the lack of criteria to determine the level of performance of the different teams being studied, an analysis of the performance of these teams in the 2 main European competitions from the 2002 through 2005 seasons was conducted. A maximum of 225 points was assigned in each sport according to the following criteria: (a) 1 and 3 points for those teams eliminated in the quarterfinals and semifinals, respectively, and 6 and 9 points for the runner-up and champion teams, respectively; (b) in the most relevant competition, the number of points allocated was doubled. Spanish sport teams obtained the highest percentage of points in indoor soccer (40.0%), handball (36.4%), and basketball (28.4%). Spanish teams in field hockey, soccer, and volleyball obtained the 21.8% (third), 14.2% (fourth), and 0.44% (14th) of the total points, respectively. A global analysis of the rankings reveals that the Spanish sports teams in first place garnered 22.6% of the total points, followed by the teams from Italy (10.4%), France (7.1%), and England (7.1%).

Survey

The survey was created by the authors and experts in questionnaire formatting; pilot testing was done with an informal advisory group of S&C coaches. The survey was divided into 5 areas of inquiry: (a) S&C coach profiles, (b) resistance training exercises, (c) resistance training load, (d) repetition velocity, and (e) training leading to failure. Most of the items in the survey were close-ended questions.

Thirteen items associated with formal education, sources of information, specific sports experience, and the contractual base were used to characterize the S&C coaches. Thirty-seven items, primarily related to the resistance training exercises proposed by Earle and Baechle (6), were chosen to characterize the exercises that the S&C coaches usually included in their training programs. Five items associated with different loads were included to define the intensity used in the exercises performed to improve dynamic athletic performance. The load intensities were selected according to the various traditional goals for resistance training that are included in the bibliography (21). For each load, the S&C coaches had to indicate if their players habitually executed the concentric phase of each repetition at the maximum possible speed and if they performed each set to muscle failure.

The survey instrument and the research design were approved by the Committee on Biomedical Ethics of the Aragon Government, Spain.

Reliability

Reliability was measured by the degree of agreement between the test and a retest performed 1 week later in 24 of the S&C coaches (4 for each sport).

Data Collection

To contact the S&C coaches, a letter describing the project was mailed to the address of the official headquarters of all the teams. The objectives of the letter were to explain the purpose of the survey, the confidentiality of information, and the researchers' motivation for conducting the survey. After 2 weeks, a telephone call to the official headquarters of the club was made to speak personally with each S&C coach. Several attempts were made to contact by telephone, letter, and e-mail those S&C coaches who could not be located initially. Ultimately, 82 S&C coaches agreed to participate in the study. Twelve S&C coaches either declined to participate or did not respond to the e-mail, letter, or telephone messages we left them. Each participating S&C coach agreed to a date for administering the survey by means of personal interview. Forty S&C coaches were interviewed when they either visited our city with their teams or were involved in competitions with several teams together in one location. The other S&C coaches were interviewed during a visit to their respective cities. Five of the 82 S&C coaches who agreed to participate in the study were not able to schedule a date for the questionnaire (Table 1).

All the interviews were conducted by a researcher with experience with qualitative methods of sports science research and content analysis.

Statistical Analyses

Data are expressed in percentages. The chi-squared test was applied to make comparisons between 2 groups of sports and between teams of class A and B for the qualitative variables associated with the profile of the S&C coaches and with the resistance training program. The Fisher test was applied if the hypothesis was not proven true. This analysis was performed for the quantitative ordinal variables by means of the Mann-

Whitney *U*-test. To observe the presence of significant differences in the percentage between 2 variables for the same group of sports, a comparison of the proportion of 2 different populations was performed. For the qualitative variables, the reliability of the test and the retest was determined by means of the McNemar test. The Spearman test was applied to measure the reliability of the quantitative ordinal variables. The α level was set at 0.05.

RESULTS

Reliability

In the reliability analysis for the qualitative variables, the *p* value was between 0.50 and 1. For all quantitative ordinal variables, correlation coefficient was 1.

Strength and Conditioning Coach Profiles

Differences Among Sports. All S&C coaches of basketball, indoor soccer, and soccer had a degree in Physical Activity and Sport Sciences, in contrast to 53.5% of the S&C coaches of handball, volleyball, and field hockey ($p < 0.001$) who had such a degree. A higher percentage of the S&C coaches of handball, volleyball, and field hockey in relation to the S&C coaches of basketball, indoor soccer, and soccer had a certification from the national federation (81.2 vs. 11.1%) and experience as a first coach (56.3 vs. 2.2%) and as a player in national leagues (43.8 vs. 4.4%) ($p < 0.001$). No S&C coach held a certification as a Strength and Conditioning Specialist (SCS).

All S&C coaches of outdoor soccer were hired full time, in contrast to 60 and 40% of the S&C coaches of basketball and indoor soccer, respectively ($p < 0.001$). In soccer, basketball and indoor soccer teams, the person responsible for the strength and conditioning program does not act as the primary coach. For the handball, volleyball and field hockey teams, 46.9% of the S&C coaches were hired full-time. Nevertheless, 50% of S&C coaches for volleyball and field hockey and 35.7% of S&C coaches for handball also act as the primary coach. Only 4 handball teams, a volleyball team, and a single hockey team have hired a full-time person exclusively for the development of the players' conditioning.

The proportion of S&C coaches, from all sports, having master and doctoral degrees in fields related to human

TABLE 1. Strength and conditioning coaches' response rates.

	Handball	Basketball	Volleyball	Indoor soccer	Soccer	Field hockey
League	ASOBAL	ACB	Super League	Honor Division	First Division	Honor Division
Number of teams ($n = 94$)	16	18	14	16	20	10
Number of teams interviewed ($n = 77$)	14	15	10	15	15	8
Total interview rate (81.8%)	87.5%	83.3%	71.4%	93.8%	75%	80.0%

performance was 22.1% and 9.1%, respectively. A high percentage of S&C coaches had attended at least 1 course of more than 20 hours in the last 3 years (77.9%), knew the physical preparation work developed by at least 1 team in his league (79.2%), and consulted journals to develop the team's conditioning program (87%). However, only 5.2% consulted journals that were included in the Science Citation Index. There were no differences among the sports for any of these variables. Also, no difference was found between the time elapsed since a coach's graduation (11.2 ± 7.3 years) or in one's experience as an S&C coach in national leagues (7.7 ± 6.7 years).

Differences by Performance Level

Significant differences were found between the teams of class A and B only for the time elapsed since graduation ($p < 0.01$). The percentage of the S&C coaches of handball, volleyball, and field hockey with a degree in Physical Activity and Sports Science was higher in Class A than in Class B teams (70.6 vs. 33.3%, $p < 0.05$). For basketball, indoor soccer, and field hockey, there were no differences among the Class A and B teams in the percentage of S&C coaches hired full time. For handball and volleyball, the percentage of S&C coaches hired full time was higher in class A than in class B teams (69.2 vs. 18.2%, $p < 0.05$). A lower percentage of class A handball and field hockey S&C coaches carried out their functions while also functioning as the team's primary coach (27.3 vs. 54.5%). The 7 handball, volleyball, and field hockey teams that had hired a full-time person exclusively for the development of the players' conditioning were all class A teams.

Resistance Training Exercises

Except for 1 indoor soccer team and 2 field hockey teams, all S&C coaches stated that weight training was included in their training programs.

Differences Among Sports. Extensors of the upper extremities: chest, shoulders, and triceps exercises: As shown in Table 2, only the barbell bench and shoulder press exercises were used by more than 50% of the teams. For handball, basketball, and volleyball, the percentage of teams that performed extensor exercises with free weights was higher than that of indoor soccer, soccer, and field hockey ($p < 0.05$). A high percentage of basketball teams, in relation to the other sports, worked with the following exercises: dumbbell bench press, shoulder press, triceps push-down, and lying barbell triceps extension ($p < 0.05$). For the handball, basketball, and volleyball teams, significant differences were found in the utilization of chest and shoulder exercises with free weights and machines ($p < 0.001$). There were no significant differences in this analysis between the indoor soccer, soccer, and field hockey teams. T2

Flexors of the upper extremities: back and bicep exercises. No flexor exercise of the upper extremities was used by more than 50% of the teams. However, we observed significant differences in the use of most of the flexor exercises among basketball teams, in comparison with the other sports. These exercises included the seated row, bent-over row, 1-arm row, barbell biceps curl, and hammer curl ($p < 0.05$).

Forearm and finger exercises. A very low percentage of teams emphasized the use of forearms and finger exercises: barbell curl and wrist extension (18.2%), dumbbell curl and wrist extension (14.3%), and curl and finger extension (2.6%).

Abdominal exercises. All the S&C coaches indicated the use of exercises to work the abdomen, including bent-knee sit-ups and crunches.

Lower extremities: hip, thigh, and calf exercises. As shown in Table 3, most of the lower-extremity exercises were used on more than 50% of the teams. The handball, basketball, and volleyball teams differed significantly in their T3

TABLE 2. Extensors of the upper extremities: chest, shoulder, and triceps exercises.*

	Handball (n = 14)	Basketball (n = 15)	Volleyball (n = 10)	Indoor soccer (n = 15)	Soccer (n = 15)	Field hockey (n = 8)	Mean (n = 77)
Flat and vertical machine bench press	7.1	13.3	10.0	33.3	40.0	37.5	23.4
Flat and incline barbell bench press	92.9	93.3	100.0	33.3	66.7	50.0	72.7
Flat and incline dumbbell bench press	28.6	53.3	20.0	6.7	20.0	12.5	24.7
Machine shoulder press	14.3	40.0	20.0	33.3	26.7	37.5	26.0
Seated barbell shoulder press	64.3	60.0	80.0	26.7	46.7	37.5	51.9
Seated dumbbell shoulder press	35.7	66.7	40.0	20.0	53.3	25.0	41.6
Triceps push-down	28.6	73.3	20.0	33.3	26.7	37.5	37.7
Lying barbell triceps extension	35.7	40.0	30.0	13.3	33.3	25.0	29.9
Dumbbell triceps kickback	28.6	53.3	40.0	0.0	20.0	50.0	29.9

*Data are expressed in percentages.

use of the barbell squat exercise in relation to the others sports ($p < 0.05$). In these sports, significant differences were observed in the percentage of teams that used barbell squats with free weights and machines ($p < 0.001$). No differences were found in regard to this comparison for indoor soccer, soccer, and field hockey teams. The percentage of teams that used the parallel barbell squat exercise was high in all sports, except in field hockey ($p < 0.01$). There were significant differences in the percentage of teams that perform full and half squat exercises ($p < 0.001$). The basketball, volleyball, and indoor soccer teams used the barbell step-up exercise to a greater extent than the teams of the other sports ($p < 0.01$). The percentage of basketball teams that performed the hip sled exercise was higher than for other sports ($p < 0.01$). Except for the handball and field hockey teams, almost all S&C coaches used the leg extension exercise ($p < 0.001$). Calf raise exercises were performed less for handball and field hockey teams ($p < 0.01$). Except for field hockey teams, a high percentage of S&C coaches used leg curl and seated hip adduction-abduction exercises ($p < 0.05$).

AU3 Power exercises. For indoor soccer, soccer, and field hockey teams, the execution of power exercises was rare ($<10\%$ of the teams). Snatch and clean exercises were performed by a high percentage of handball (78.6 vs. 50.0%), basketball (40.0 vs. 46.7%), and volleyball (70.0 vs. 90.0%) teams. The execution of push press and/or push jerk exercises was rare in all sports, except for volleyball (50.0%).

Ballistic exercises. The majority (64.9%) of teams performed the load squat jump exercise, with significant differences between handball and basketball teams (82.8%) compared with the remaining sports (54.2%) ($p < 0.05$). No team implemented the bench press throw exercise.

Other exercises. A total of 12 additional exercises were indicated by at least 1 S&C coach. Only 3 exercises were noted for more than 20% of S&C coaches: the bent-arm dumbbell pullover (37.7%), the bent-arm barbell pullover (28.6%), and the flat and inclined dumbbell fly (22%).

Global analysis of the most used exercises. In summary, the exercises that were implemented by more than 50% of S&C coaches are shown for each sport in Table 4.

T4

Differences by Performance Level. Only for the leg curl exercise was a statistical significance observed between teams of class A and B ($p < 0.05$). This difference was observed exclusively for the soccer teams (100 vs. 42.9%, $p < 0.05$). The groups of different sports exhibited significant differences among teams of class A and B for the following exercises: the flat and incline barbell bench press exercise in indoor soccer and field hockey teams (72.7 vs. 8.3%, $p < 0.01$); the barbell forward lunge for indoor soccer, soccer, and field hockey teams (57.9 vs. 21.1, $p < 0.05$); the load squat jump for the handball and basketball teams (100.0 vs. 64.3%, $p < 0.05$); and the lat pull-down exercise for the soccer and field hockey teams (66.7 vs. 18.2%, $p < 0.05$).

Resistance Training Load

Differences Among Sports. Load intensity: Five S&C coaches (1 of handball and 4 of soccer) were excluded from this analysis, as they stated that they do not control the load intensity. Table 5 shows the percentage of S&C coaches who reported working with different load intensities.

T5

Only 12.5% of S&C coaches work with a resistance $<30\%$ of 1RM. The number of teams that work with a load of 30–50% of 1RM was also very low, except for the soccer teams ($p < 0.01$). Most S&C coaches (73.6%) stated that they

TABLE 3. Hip, thigh, and calf exercises.*

	Handball (n = 14)	Basketball (n = 15)	Volleyball (n = 10)	Indoor soccer (n = 15)	Soccer (n = 15)	Field hockey (n = 8)	Mean (n = 77)
Machine squat	21.4	33.3	10.0	33.3	26.7	25.0	26.0
Barbell squat	50.0	60.0	80.0	33.3	40.0	37.5	49.4
Parallel barbell squat	85.7	86.7	100.0	80.0	86.7	37.5	81.8
Barbell step-up	50.0	73.3	80.0	73.3	53.3	12.5	59.7
Barbell forward lunge	35.7	53.3	50.0	33.3	53.3	25.0	42.9
Hip sled	57.1	93.3	20.0	73.3	60.0	37.5	61.0
Leg extension	57.1	80.0	90.0	93.3	86.7	37.5	76.6
Machine standing and seated calf raise	35.7	60.0	30.0	80.0	60.0	37.5	53.2
Barbell calf raise	28.6	66.7	70.0	46.7	60.0	0.0	48.1
Leg curl	71.4	80.0	100.0	86.7	73.3	37.5	76.6
Seated hip adduction-abduction	68.3	80.0	100.0	73.3	73.3	37.5	72.7

*Data are expressed in percentages.

TABLE 4. Most used exercises for each sport.

Number	Handball (n = 14)		Basketball (n = 15)		Volleyball (n = 10)		Indoor soccer (n = 15)		Soccer (n = 15)		Field hockey (n = 8)	
	Exercise	%	Exercise	%	Exercise	%	Exercise	%	Exercise	%	Exercise	%
1	Flat and incline barbell bench press	92.9	Flat and incline barbell bench press	93.3	Flat and incline barbell bench press	100.0	Leg extension	93.3	Leg extension	86.7	Flat and incline barbell bench press	50.0
2	Parallel barbell squat	85.7	Hip sled	93.3	Parallel barbell squat	100.0	Parallel barbell squat	80.0	Parallel barbell squat	86.7	Dumbbell triceps kickback	50.0
3	Load squat jumps	85.7	Parallel barbell squat	86.7	Clean and jerk	90.0	Machine standing and seated calf raise	80.0	Flat and incline barbell bench press	66.7		
4	Snatch	78.6	Load squat jumps	80.0	Leg extension	90.0	Step-up	73.3	Load squat jumps	60.0		
5	Seated barbell shoulder press	64.3	Leg extension	80.0	Barbell squat	80.0	Hip sled	73.3	Hip sled	60.0		
6	Leg extension	57.1	Hammer curl	80.0	Seated barbell shoulder press	80.0	Load squat jumps	66.7	Machine standing and seated calf raise	60.0		
7	Hip sled	57.1	Barbell biceps curl	73.3	Step-up	80.0			Barbell calf raise	60.0		
8	Step-up	50.0	Step-up	73.3	Snatch	70.0			Hammer curl	60.0		
9	Clean and jerk	50.0	Triceps push-down	73.3	Barbell calf raise	70.0			Seated dumbbell shoulder press	53.3		
10			Seated dumbbell shoulder press	66.7	Push press and/or push jerk	50.0			Barbell biceps curl	53.3		
11			Barbell calf raise	66.7	Forward lunge	50.0			Step-up	53.3		
12			Seated barbell shoulder press	60.0	Lat pull-down	50.0			Forward lunge	53.3		
13			Lat pull-down	60.0								
14			Barbell squat	60.0								
15			Machine standing and seated calf raise	60.0								
16			Dumbbell triceps kickback	53.3								
17			Flat and incline dumbbell bench press	53.3								
18			Forward lunge	53.3								

TABLE 5. Relative intensity of load by sport.*†

	Handball (n = 13)	Basketball (n = 15)	Volleyball (n = 10)	Indoor soccer (n = 15)	Soccer (n = 11)	Field hockey (n = 8)	Mean (n = 72)
<30% of 1RM	15.4	6.7	20.0	13.3	9.1	12.5	12.5
30–50% of 1RM	30.8	26.7	20.0	21.4	72.7	12.5	30.6
50–70% of 1RM	76.9	66.7	90.0	73.3	81.8	50.0	73.6
70–90% of 1RM	84.6	100.0	100.0	73.3	81.8	62.5	84.7
90–100% of 1RM	53.8	33.3	70.0	26.7	9.1	0.0	33.3

*1RM = 1 repetition maximum.

†Data are expressed in percentages.

worked with 50–70% of 1RM, with no significant differences found among sports. Across all sports, a load intensity of 70–90% of 1RM was the most used. This load was used for all basketball and volleyball teams, compared with 76.6% for the other sports ($p < 0.01$). Except for handball and volleyball teams, a low percentage of S&C coaches used intensities of 90–100% of 1RM ($p < 0.01$).

Optimal training load. Thirteen teams did not work with different load intensities. All handball, volleyball, and soccer teams used different load intensities, compared with 80.0% of basketball teams and 56.5% of indoor soccer and field hockey teams ($p < 0.001$). In addition, 11 teams did not work with the minimal load recommended, 50–90% of 1RM. A great variety in the rank of load intensity was observed in the 48 teams (66.6%) that worked with the optimal load: 50–90% of 1RM (29.2%), 30–90% of 1RM (11.1%), 50–100% of 1RM (11.1%), 30–100% of 1RM (8.3%), and <30 to 100% of 1RM (6.9%). There were no significant differences among sports in the percentage of teams that worked with the optimal load. Nevertheless, the difference observed between volleyball and the other team sports was notable (90.0 vs. 62.9%).

Differences According to Performance Level. Load intensity: A majority of class A teams (94.7%) worked with a resistance of

70–90%, compared with 73.5% of the class B teams ($p < 0.05$). Similar results were obtained among teams of class A and B of handball, basketball, and field hockey for an intensity of 50–70% of 1RM (84.2 vs. 47.1%, $p < 0.05$).

Optimal training load. A large percentage of Class A teams (78.9%), in comparison with 52.9% of class B teams, used an optimal combination of load ($p < 0.05$). The following percentages of class A teams used the optimal training load: handball (100%), basketball (87.5%), volleyball (83.3%), field hockey (75%), indoor soccer (71.4%), and soccer (50%).

Repetition Velocity

Differences Among Sports. In 6 out of the 9 teams that worked at an intensity <30% of 1RM, the S&C coaches indicated performing the maximum repetition velocity. This percentage decreased to 45.5, 30.2, and 39.3%, respectively, for loads of 30–50, 50–70, and 70–90% of 1RM, respectively. For an intensity of 90–100% of 1RM, 66.7% of teams executed the repetitions at maximum speed. A greater percentage of handball, basketball, volleyball, and field hockey teams in relation to indoor soccer and soccer teams performed the maximum repetition velocity at a resistance of 50–70% of 1RM (42.4 vs. 10.0%, $p < 0.05$). Similar results were obtained among soccer and field hockey teams, compared with the

TABLE 6. Combination of repetition velocity and muscular failure for each load.*

	Maximum speed and nonfailure	Maximum speed and failure	Not maximum speed and nonfailure	Not maximum speed and failure
<30% of 1RM (n = 9)	66.7	0.0	33.3	0.0
30–50% of 1RM (n = 22)	45.5	0.0	54.5	0.0
50–70% of 1RM (n = 53)	30.2	0.0	62.3	7.5
70–90% of 1RM (n = 61)	31.1	8.2	36.1	24.6
90–100% of 1RM (n = 24)	25.0	41.7	8.3	25.0

*Data are expressed in percentages.

other teams, for a load of 70–90% of 1RM (14.3 vs. 46.8%, $p < 0.05$).

Differences by Performance Level. Maximum repetition velocity was higher in class A than in class B teams at intensities of 50–70% of 1RM (50.0 vs. 27.3%), 70–90% of 1RM (57.1 vs. 26.7%), and 90–100% of 1RM (87.5 vs. 54.5%), although there was no significant difference.

Training Leading to Failure

Differences Among Sports. No S&C coach implemented training leading to repetition failure with a resistance $< 50\%$ of 1RM. The percentage increased progressively with the load intensity: 7.5% at 50–70% of 1RM, 32.8% at 70–90% of 1RM, and 66.7% at 90–100% of 1RM. There was no significant difference found among sports regarding muscular failure.

Differences According to Performance Level. No class A teams executed to muscular failure at an intensity of 50–70% of 1RM compared with 17.4% of class B teams ($p < 0.05$). There were no significant class differences at the other intensities.

Combination of Repetition Velocity and Muscular Failure

In summary, the percentage of teams that depended on one of 4 possible combinations of repetition velocity and muscular failure is represented for each load in Table 6.

Association Among the Profiles of the Strength and Conditioning Coaches and Resistance Training Variables

Variables associated with the formal education, the contractual base, and the functions accomplished determined the S&C coaches' different profiles. Table 7 shows the association between these variables and selected resistance training variables.

Regarding formal education, significant differences were only found in the use of Olympic exercises among the S&C coaches with a national certificate and the S&C coaches with a university degree ($p < 0.05$). Similar analysis was done grouping different sports. For the basketball, indoor soccer, and soccer teams, only the master's and/or doctoral degrees determined differences in the S&C coaches' formal education. In these sports, use of the optimal combination of repetition velocity and muscular failure for a load of 50–70% of 1RM was influenced by whether the coach had a degree in Physical Activity and Sport Science ($n = 26$) or a master's and/or doctoral degrees ($n = 15$) (4.8 vs. 55.6%, $p < 0.05$). For the handball, volleyball, and field hockey teams, having a university degree in addition to a national certificate was the variable associated with formal education that determined a different S&C coach profile. In these sports, there were no significant differences in the resistance training programs of the S&C coaches both with a degree in Physical Activity and Sports Science and holding a National Federation certificate ($n = 13$), and the S&C coaches who had accomplished only one of the 2 credentials ($n = 19$).

In the analysis of the contractual base of the S&C coaches, it was observed that full-time S&C coaches used better

TABLE 7. Association between the profile of the strength and conditioning coaches and selected resistance training variables.

	Barbell squat exercise	Parallel barbell squat exercise	Load squat jumps exercise	Olympic-style lift exercises	Leg curl exercise	Optimal load (50–70% of 1RM)	Maximum repetition speed and no failure (70–90% of 1RM)
Formal education							
PASS degree and Sport National Certificate ($n = 18$)	50.0	83.3	61.1	50.0	77.8	61.1 ($n = 18$)	37.5 ($n = 16$)
PASS ($n = 45$)	48.9	80.0	66.7	33.3	77.8	68.3 ($n = 41$)	28.6 ($n = 35$)
Sport National Certificate ($n = 14$)	50.0	85.7	64.3	78.6	71.4	69.2 ($n = 13$)	30.0 ($n = 10$)
Contractual base of the strength and conditioning coaches							
Full time ($n = 45$)	44.4	88.9	68.9	37.8	82.2	78.0 ($n = 41$)	27.0 ($n = 37$)
Part time ($n = 32$)	56.3	71.9	59.4	56.3	68.8	51.6 ($n = 31$)	37.5 ($n = 24$)
Functions accomplished by the strength and conditioning coaches							
Conditioning ($n = 63$)	49.2	84.1	66.7	41.3	79.4	63.8 ($n = 58$)	30.0 ($n = 50$)
Conditioning and first coach ($n = 14$)	50.0	71.4	57.1	64.3	64.3	78.6 ($n = 14$)	36.4 ($n = 11$)

combinations of load intensity than the S&C coaches hired part time ($p < 0.05$). This difference was found only for handball and field hockey teams (90.9 vs. 30.0%, $p < 0.05$).

AU4

No association was established in relation to the functions accomplished by the S&C coaches, nor were there differences in the resistance training programs among the S&C coaches with an academic degree, hired full time, and who did not function as the primary coach ($n = 36$) compared with the S&C coaches who did not meet one of these 3 conditions ($n = 41$).

DISCUSSION

This work represents the first study to examine the most relevant aspects of resistance training in the most popular European team sports. Furthermore, a high reliability was obtained for all items, and, except in volleyball, Spanish teams evidence an optimal performance in the European competitions.

The results of this study show that the S&C coaches' profiles are associated with the level of professionalization of the teams. Thus, all professional league basketball and soccer teams have hired, exclusively for the development of the players' conditioning, an S&C coach with a degree in Physical Activity and Sport Sciences. Additionally, all S&C coaches of soccer and 60% of the S&C coaches of basketball were hired full time. Similarly, 57.1% of the class A teams of handball had a full-time S&C coach, with a university degree. Although the Spanish handball league is not officially of professional rank, the better teams are considered semi-professional; they hire the best players from around the world and they compete successfully in the European competitions. In contrast, in a high percentage of the class B teams for handball and for amateur volleyball and hockey teams, conditioning is implemented by the primary coach. For the remaining teams, the conditioning is implemented by a part-time person with a university degree. These results suggest that the more professional teams with larger budgets take very seriously the strength and conditioning needs of their athletes and are trying to protect and better prepare them for competition.

The number of years after obtaining a degree, experience as an S&C coach for top class teams, postgraduate degrees, or sources where information can be found were not found to be determining factors for the decision to hire a given S&C coach.

Of special interest is the fact that during the years after one's graduation as an S&C coach (11.2 ± 7.3 years), only a very small percentage went on for more academic training (master's or doctoral degrees) or consulted journals included in the Science Citation Index. The percentage of S&C coaches with a master's degree is lower in Spain than in American and Canadian professional leagues during the 1994–95 season for baseball, basketball, American football, and ice hockey teams (36), and was also lower than American collegiate S&C coaches (5). Durrel et al. (5) surveyed Division I S&C coaches and found that 94% of the respondents consult the *Strength*

and Conditioning Journal, 34% the *Journal of Medicine and Science in Sport and Exercise*, and around 10% the *Journal of Strength and Conditioning Research*. Only 5.2% of Spanish S&C coaches consulted journals that were included in the Science Citation Index, and no one consulted the journals published by the National Strength and Conditioning Association. Probably, these differences may be an indication of the lower rate of growth of the field of conditioning in Spain.

Based on these findings, the possibility exist that many strength and conditioning programs may be based on sources that lack scientific credibility. In fact, important deficiencies were found in various components of the resistance training programs for the physical development of elite Spanish team players.

Our results concerning specific exercises used in team sports differ from those of other surveys, which have indicated that variations of Olympic lifts and squats are the most commonly used exercises in professional (7–9,35) and collegiate athletics (5). We found that only handball and volleyball S&C coaches used Olympic exercises, and, except for volleyball, there was a great difference in the utilization of full and half squat exercises. Olympic-style lifts are considered some of the best training exercises to maximize athletic performance (13,16). Full squat exercises are necessary for the prevention of knee injuries (33).

As a consequence, a great variety of single-joint exercises are used by indoor and outdoor soccer teams and especially basketball teams. In fact, leg extension was the exercise most used by S&C coaches of indoor soccer and soccer. Leg extension exercise can be adequate for postinjury strengthening, but their efficacy in enhancing performance is doubtful (31). The use of too many exercises can result in excessive resistance training. Regarding this matter, various studies have established an optimum threshold on the volume of training (2,14).

In field hockey, 25% of the respondents do not use resistance training exercises, and for the remaining teams, a specific exercise program was not observed.

The S&C coaches in our survey did not use the bench press throw exercise, and except for in handball and basketball, most S&C coaches did not include the load squat jump in their training programs. Today, it is known that ballistic resistance techniques are useful for improving muscular power and dynamic athletic performance because they limit the deceleration phase (29).

None of the flexor exercises of the upper extremities are used by more than 50% of the teams. This may imply a greater risk of injury to the dominant upper extremity. In the same way, strength imbalance is possible between antagonist and agonist muscles of the lower extremities in athletes playing field hockey and class B soccer who did not perform leg curl and hip adduction-abduction exercises.

AU5

It was also evident that the S&C coaches did not know the optimal load intensity for resistance training. In fact, a great variety of load intensities were noted among those identified.

Only the volleyball teams and a number of the class A handball, basketball, field hockey, and indoor soccer teams work with a load of 50–90% of 1RM. These data reveal an inadequate loading strategy for many of the teams analyzed. According to the conclusions of numerous studies, this load intensity is necessary to increase maximum muscle strength and to result in enhanced muscle power and dynamic performance (19,21,25,32,39).

In relation to repetition velocity and training leading to failure, the unique common criterion of most of the studied teams was to not perform the maximum number of repetitions with a resistance <70% of 1RM. But, even at these intensities, the majority of the S&C coaches do not propose the exercises be performed at the maximum movement velocity. Our results revealed that the players of these teams do not develop maximum power in any of their repetitions. Some authors suggest that repetition velocity can be associated with selective hypertrophy of muscle fibers and with fiber type transformations (11). According to Lawton et al. (22), executing the number of repetitions that can be performed at maximum speed can induce selective hypertrophy of fast twitch fibers and permit greater transfer of training effects to improve the speed of specific competitive skills.

This study demonstrates that there are significant differences between sports and between teams of the same sport in the use of scientifically based resistance training practices. More significant deficiencies in the fundamental principles of resistance training were found in the class B basketball and handball teams and, especially, among soccer, indoor soccer, and field hockey teams.

An attempt was made to determine if the S&C coach profiles were associated with the teams' resistance training programs. Variables associated with the formal education, the contractual base, and the functions accomplished determined the S&C coaches' different profiles. Neither were there differences in the resistance training programs among the S&C coaches with an academic degree, hired full time, and who did not function as the primary coach compared with the S&C coaches who did not meet one of these 3 conditions.

It is possible that some of the differences between sports and between teams of different performance levels may be a result of many factors, including the strength training culture that has historically developed in each sport, the professional level, the conditioning services offered by the clubs, the time dedicated to the conditioning training, the competition calendar, the staff to athlete ratio, the difficulty of getting athletes and coaches to buy into the program, dual responsibilities, and the amount of emphasis given to injury prevention rather than performance enhancement.

The overall results of the survey suggest that the resistance training programs used for many teams differ significantly in the amount of scientific knowledge (3,10,18,19,21,22,27) embedded in the recommended programs for the physical development of team players (3,4,12,23,24,26). These results also differ from comparable data that have been previously

reported in surveys of professional (7–9,35) and collegiate athletes (5).

In addition to the need for Spanish S&C coaches to pursue master's degrees and consult scientific journals, probably the differences found in the application of resistance training programs between the Spanish teams and the professional (36) and college league (5) teams, be also proper to than a high percentage of these S&C coaches have specific training in strength and conditioning practices, such as the National Strength and Conditioning Association (NSCA) Certified Strength and Conditioning Specialist (CSCS).

PRACTICAL APPLICATIONS

This study reveals important deficiencies in the resistance training programs of elite sports teams. These results should provoke reflection of the S&C coaches of these teams and lead them to question their methods of work and to justify the need for scientific and specific education. In the same way, this work should serve as feedback to the scientific community and to the S&C coaches of other teams on a variety of issues: (a) knowledge of the resistance training used by sports teams with success in European competitions; (b) the need to resolve numerous questions on the optimum resistance training in these sports; (c) the need to improve strategies for disseminating scientific knowledge to the S&C coaches involved in the development of elite athletes; and (d) the need to identify a productive model for accomplishing similar work in another countries, sports, and institutions, and for determining the needed changes in the teams analyzed in this study.

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