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Training program influences the relation between functional and neuromuscular performance indicators during the season in young soccer players

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Abstract   The aim of this study was to investigate the influence of a training program on the relation between performance indicators of different physical capacities intra and inter functional and neuromuscular systems at different times of the season. Subjects were 16 young soccer players with an average age of 16.5 ± 0.4 years. The study was carried out for 17 weeks, including three assessment moments (T1: 1st, T2: 10th and T3: 17th week). High correlation was found between indicators of neuromuscular predominance (30 meters sprint test (30 m) and Maximum Sprint (MaxSprint) (RAST) in T1) ($r = 0.93$, $p \leq 0.001$), functional (Sprints Average (MidSprint) and Minimal Sprint (MinSprint) (RAST) in T1, T2 and T3; MinSprint and Fatigue Index (FI) (RAST) in T3) ($r = 0.95$, 0.85, 0.91; -0.86, $p \leq 0.001$, respectively) and between functional and neuromuscular indicators (30 m and MidSprint in T1; 30 m and MinSprint in T1; MaxSprint and MidSprint in T1 and T2 and MaxSprint and MinSprint in T1) ($r = 0.95$, 0.93, 0.96, 0.84, 0.87, $p \leq 0.001$, respectively). The training contents had influence on the correlation of performance indicators at different times of the season.
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Programa de treinamento influencia a relação entre os indicadores de desempenho funcional e neuromusculares durante a temporada em jovens futebolistas

Resumo   O objetivo do presente estudo foi verificar a influência de um programa de treinamento na relação entre indicadores de desempenho de diferentes capacidades físicas intra e inter sistema funcional e neuromuscular em diferentes momentos da temporada. Participaram do estudo 16 jovens futebolistas com idade média de 16,5 ± 0,4 anos. O estudo decorreu por 17 semanas, incluindo três momentos de avaliação (T1:1ª; T2:10ª e T3:17ª semana). Foram encontradas alta correlação entre indicadores de predominância neuromuscular (Sprints em 30m (30m) e Sprint Máximo (MaxSprint) (RAST) em T1) (r = 0,93; P ≤ 0,001), funcional (Média de Sprints (MidSprint) e Sprint Mínimo (MinSprint) (RAST) em T1, T2 e T3; MinSprint e Índice de Fadiga (FI) (RAST) em T3) (r = 0,95; 0,85; 0,91; -0,86; P ≤ 0,001, respectivamente) e entre funcional e neuromuscular (30 m e MidSprint em T1; 30 m e MinSprint em T1; MaxSprint e MidSprint em T1 e T2 e MaxSprint e MinSprint em T1) (r = 0,95; 0,93; 0,96; 0,84; 0,87; P ≤ 0,001, respectivamente). Os conteúdos de treinamento exerceram influência na correlação dos indicadores de rendimento nos diferentes momentos da temporada.

Un programa de formación influye en la relación entre los indicadores de rendimiento funcionales y neuromusculares durante la temporada en futbolistas jóvenes

Resumen   El objetivo de este estudio fue investigar la influencia de un programa de formación en la relación entre los indicadores de desempeño de las diferentes capacidades físicas intra y intersistemas funcionales y neuromusculares, y en diferentes momentos de la temporada. En el estudio participaron 16 jugadores de fútbol jóvenes con una media de edad de 16,5 ± 0,4 años. El estudio duró 17 semanas, incluyendo tres momentos de evaluación (T1: 1.ª; T2: 10.ª y T3: 17.ª semana). Se encontró una alta correlación entre los indicadores de prevalencia neuromuscular [sprints en 30 m (30 m) y sprint máximo (MaxSprint; RAST) en T1 (r = 0,93; P ≤ 0,001)], funcional [sprint medio (MidSprint) y sprint mínimo (MinSprint; RAST) en T1, T2 e T3; MinSprint e índice de fatiga (FI; RAST) en T3 (r = 0,95; 0,85; 0,91; −0,86; P ≤ 0,001, respectivamente)] y entre funcional y neuromuscular [30 m y MidSprint en T1; 30 m y MinSprint en T1; MaxSprint y MidSprint en T1 y T2, y MaxSprint y MinSprint en T1 (r = 0,95; 0,93; 0,96; 0,84; 0,87; P ≤ 0,001, respectivamente)]. Los contenidos de la formación han influido en la correlación de los indicadores de rendimiento en diferentes momentos de la temporada.

Introduction

Soccer is one of the most practiced sports in the world, which awakes many researchers' interest on better understanding its specificities regarding performance components, such as the physical, the technical, the tactical, the psychological and others ones (Stolen et al., 2005; Bangsbo, 2006; Silva et al., 2008). Most of these studies aim to investigate the physical component, related to the sport competitive performance.

Specifically in relation to the physical component, it is known that the efforts that soccer players perform are intermittent, composed of displacements at intensities which range from walks to low-moderate intensity running and intense sprints (Stolen et al., 2005; Di Salvo et al., 2007; Bradley et al., 2009). They also perform deflections, twirls (Bloomfield et al., 2007), jumps, and specific technical actions (Mohr et al., 2003; Rampinini et al., 2007) which require high coordinative patterns, totalizing 1000–1400 actions during the match, which alternate every 4–5 s (Thomas and Reilly, 1979; Bangsbo, 1996).

This fact shows that a soccer player performance is guided and sustained by the manifestation of several physical capacities and their subdivisions, since they are interrelated and, therefore, not manifested in an isolated way. Such interrelations cannot be restricted or decoupled in relation to the influences of the training content, since there is the predominance of a specific manifestation over the other, but not the restriction or exclusive development of the trained physical capacity.

This information is attested by studies that found correlations between different physical capabilities or their manifestation (Wisloff et al., 2004; Little and Williams, 2005; Meckel et al., 2009), demonstrating that when there is a strong correlation between them, the effects of training may be similar or beneficial to both (positive correlation), or extremely distinct (negative correlation), so that different stimuli are necessary in order to improve both of them.

A sports modality with intermittent characteristics, such as soccer, presents several manifestations of physical abilities which are responsible for predominant and determining actions, which need heterochrony or harmony so that certain actions and/or performance are not negatively affected. For this reason, it is important to present which and how abilities correlate, as well as how they respond to the applied training.

Specific research, which analyzed the correlation levels only in a certain moment or season situation (Coelho et al., 2011; Souza et al., 2012; Ingebrigtsen et al., 2014), aimed to identify whether the tests are appropriate to assess the capacities that they are intended to assess, as well as to verify if one physical capacities presents levels that may potentialize the performance of others. Such researches do not ensure that these levels will remain unaltered throughout the training program, since no study has examined the influence of the training content on the correlation levels between the capacities, which may be naturally changed, indicating adjustments that can lead to more prolonged improvement of some indicators which may be important for the manifestation of other physical capacities and also lead to performance improvement.

The initial hypothesis of the study is that predominantly neuromuscular content training may have positive influence and raise correlation levels between indicators of capacities with this predominance, while functional content training may increase the correlation between capacities with the same characteristics (intra-system). However, it is unknown how much influence one predominant system (neuromuscular or functional) can exert in the manifestation of physical capabilities of another predominant system (intersystem).

Therefore, the aim of this study was to investigate the correlation between different physical capacities performance indicators, intra and intersystems, at different periods of a soccer season. The results may show whether certain physical capacities influence or are related to others and whether training influences the relation responses among physical capacities.

Materials and methods

Experimental design

This study aimed to verify the influence of a training program in the correlation levels of physical capacity indicators, assessed throughout a team's competitive period during the Under-17 São Paulo Championship (State of São Paulo – Brazil). The team training program lasted for 17 weeks, during which 93 training sessions and 13 official matches were conducted, as well as three assessment sessions which occurred before the first week (T1), after the tenth week (T2) and after the 17th week (T3). In each assessment session, subjects took the Counter Movement Jump test (CMJ); speed test over 10 meters (10 m) and 30 meters (30 m); the Running-based Anaerobic Sprint Test (RAST) and the Yo-Yo Intermittent Recovery Test – Level 2.

This study was reviewed by the Committee for Research Involving Human Subjects of the Methodist University of Piracicaba (UNIMEP), and approved under protocol # 43/08.

Subjects

The group of subjects assessed in this study was composed of 16 soccer players with an average systematized soccer practice of four years. There were five defensive athletes, six midfielders and five forward athletes, with age mean of 16.55 ± 0.47 years, body mass mean of 69.42 ± 6.1 kg, height mean of 179 ± 7 cm and predicted body fat mean of $7.74 \pm 3.30\%$. Goalkeepers were excluded, since their training program has some particularities in relation to other athletes' training.

Tests

In order to avoid learning influences in the adopted performance tests, athletes were familiarized with the equipments and protocols and instructed on the correct tests execution, prior to the collection of valid measures for the study.

Before each test, the assessed subjects warmed-up with general and specific exercises in order to minimize physiological influences caused by the lack of preparation for the tests exercises.

Counter movement jump

For determining lower limbs power, the Counter Movement Jump (CMJ) test was adopted in accordance with Bosco et al. (1983), which provided a jump height indicator in centimeters (cm), measured by a Jump System Pro contact platform (Cefise®, São Paulo – Brazil). Each athlete performed the test three times, being the best result the one considered for analysis purposes.

Speed over 10 and 30 m

The speed test over 30 m followed the protocol described by Svensson and Drust (2005), which aimed to assess the average speed of athletes at 10-meter (10 m) and 30-meter (30 m) distances, by the use of three Speed Test Fit photocells (Cefise®, São Paulo – Brazil) with a precision of 0.01 s, placed at the starting line, at 10 m and 30 m. The athletes were positioned standing up on the starting line and, at the evaluator signal, started running the defined distance as fast as possible. Every subject took the test twice, with a 5-min interval, and the times were recorded in each distance, for subsequent average speed calculation in meters per second (m/s).

Table 1 Percentage of time spent with each predominantly functional and neuromuscular manifestation and number of training sessions, official matches and assessment sessions.

(min – %)	Physical capacity	Physical capacity manifestations	Training weeks																
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Functional																			
(4300 min. – 76.5%)	Endurance	General endurance	9.7	7.1	5.5	7.9	–	3.4	6.3	–	–	7.2	–	2.7	–	–	–	–	–
		Speed endurance	2.4	–	–	–	–	–	–	10.1	–	1.8	–	17.3	–	–	–	–	8.8
		Specific endurance	62.8	74.7	76.4	71.9	63.7	71.6	60.0	73.4	77.4	75.8	–	34.7	89.2	86.2	72.3	88.4	52.6
Total (%)			74.9	81.8	81.8	79.8	63.7	74.2	66.3	83.5	77.4	84.8	–	54.7	89.2	86.2	72.3	88.5	61.4
Neuromuscular																			
	Strength*	Strength endurance	19.3	16.2	14.5	18.0	11.0	4.5	16.8	–	–	–	–	21.3	10.8	10.0	12.3	–	–
		Power	1.0	2.0	3.6	2.2	6.6	2.3	4.2	1.3	1.6	0.7	–	–	–	–	3.1	6.6	21.1
(1316 min. – 34.5%)	Speed	Acceleration capacity	2.4	–	–	–	14.3	1.1	–	–	6.5	1.8	–	–	–	–	3.1	4.9	8.8
		Maximum speed	2.4	–	–	–	–	–	–	–	8.1	1.8	–	2.7	–	–	–	–	8.8
		Agility	–	–	–	–	2.2	4.5	–	–	6.5	–	–	–	–	–	–	–	–
	Motor skills	General motor skills	–	–	–	–	2.2	6.8	6.3	7.6	–	10.8	–	17.3	–	–	–	–	–
		Specific motor skills	–	–	–	–	–	6.8	6.3	7.6	–	–	–	4.0	–	3.8	9.2	–	–
Total (%)			25.1	18.2	18.2	20.2	36.3	25.8	33.7	16.5	22.6	15.2	–	45.3	–	13.8	27.7	11.5	38.6
Training sessions (n)			6	7	4	6	7	7	7	6	5	6	0	7	5	7	4	6	3
Official matches (n)			1	1	1	1	1	1	1	1	1	1	0	0	0	1	1	1	0
Assessment time			T1											T2					T3

The symbol – indicates 0.0% of time.

  * Maximum strength and specific strength manifestations were not observed, since, in the 17 weeks, the contents were not predominant in such manifestations.

Running-based anaerobic sprint test (RAST)

The Running-based Anaerobic Sprint Test (RAST) was used for collecting indicators related to speed endurance. In this test, athletes had to run the distance of 35 m, 6 times, in the maximum possible speed, with rest periods of 10 s between the runs. Two Speed Test Fit photocells (Cefise®, São Paulo – Brazil), located at the beginning and at the end of the 35 m, were used to collect the times. Four indicators were obtained: the highest mean displacement speed obtained in a test run (MaxSprint), the mean of the average speeds in the six runs that compose the test (MidSprint), the lowest mean speed in one of the repetitions (MinSprint) and the percentage of the mean speed values decrease, from the highest to the lowest performance in the test, represented by the fatigue index (FI) (Zacharogiannis et al., 2004).

Yo-Yo intermittent recovery test – level 2

In order to assess specific endurance (intermittent – anaerobic/aerobic), the Yo-Yo Intermittent Recovery Test – Level II (Yo-Yo IR2) protocol proposed by Bangsbo (1996) was followed, in which the total distance covered in the test, in meters (m), was adopted as an indicator of the assessed physical capacity performance. The test consists of running a 20-m distance, turning and returning to the starting point, according to a beep. After that, the athlete has 10 s of recovery. In every run, the athlete must pass at least one foot beyond the distance demarcation, and if for the second consecutive time this cannot be performed, the test is stopped and the last reached distance (m) is considered the test result. The result is recorded in the same way in case of withdrawal by exhaustion, even if the two faults do not occur.

Classification of training sessions

For the evaluation of the weekly organization of the training sessions, the contents were classified according to the adaptation predominantly required for the training session. For the functional system, all the training which focused on endurance adaptations was included, that is, general endurance (or aerobic), speed endurance (or anaerobic) and specific endurance (anaerobic/aerobic), since they are mainly related to the power supply system which ensures effective performance, and because of the relation to the sports characteristic stimuli. The neuromuscular system training was composed of sessions that focused predominantly on strength adaptations and its manifestations (strength endurance, maximal strength, power and specific strength – combination of strength manifestations which are similar or equal to the modality specific movements). It also focused on the speed capacity and its manifestations (acceleration capacity, maximum speed, agility) and on motor skills (general and specific motor skills – actions for the improvement of the sports specific movements). This system has such configuration, since its development is directly related to the nervous and muscular systems (Gomes and Souza, 2008).

Table 1 presents the functional and neuromuscular development percentage values, from the predominant physical capacity manifestation.

Classification of performance indicators

Following the training content classification, performance indicators were also gathered in two groups, according to predominance. In the neuromuscular system group, there are CMJ, 10 m, 30 m and MaxSprint, while MidSprint, MinSprint, FI and Yo-Yo IR2 composed the group of functional system predominance, according to Table 2.

Statistical procedures

Initially, data normality was checked by the Shapiro–Wilk test. To verify the correlation levels between the variables in the different assessed moments, the Pearson Correlation Coefficient test was used, with significance level of 1% ($p \leq 0.001$).

For verifying the correlation between the assessing moments, the one-way analysis of variance (ANOVA) was used and, when necessary, it was complemented by Bonferroni post hoc test with significance level of 5% ($p \leq 0.05$). For data analysis, the software BioEstat® 5.0 for Windows® was used.

Table 2 Classification of performance indicators, according to neuromuscular and functional predominance.

Neuromuscular	Functional
CMJ – (power) jump height (cm) with the countermovement technique.	MidSprint – (speed endurance) mean speed (m/s) in the RAST six runs.
10 m – (speed) mean displacement speed (m/s) in 10 m.	MinSprint[a] – (speed endurance) lowest mean displacement speed (m/s) in RAST.
30 m – (maximum speed) mean displacement speed (m/s) in 30 m.	FI – (speed endurance) percentage of performance decrease (%) from the highest to the lowest mean speed in RAST.
MaxSprint – (maximum speed) highest mean displacement speed (m/s) in 35 m – RAST.	Yo-Yo IR2 – (specific/intermittent endurance) total distance covered (m) during the test.

[a] The stimuli of the MinSprint indicator have the same characteristics of the stimuli used for measuring MaxSprint. However, MinSprint is under the influence of previous stimuli, so that this indicator's values are commonly observed in the fifth or sixth RAST run, while the MaxSprint occurs in the first or second run.

Table 3 Performance indicators in different assessment moments (mean ± SD).

Performance indicators	Assessment moments		
	T1	T2	T3
CMJ (cm)	44.02 ± 5.05	43.69 ± 5.05	42.58 ± 4.44
10 m (m/s)	5.03 ± 0.38	5.04 ± 0.31	5.19 ± 0.23
30 m (m/s)	7.26 ± 0.20	7.09 ± 0.24[a]	6.97 ± 0.24[b]
MaxSprint (m/s)	7.25 ± 0.19	7.12 ± 0.24[a]	7.03 ± 0.20[b]
MidSprint (m/s)	6.70 ± 0.19	6.65 ± 0.21	6.51 ± 0.24[b,c]
MinSprint (m/s)	6.18 ± 0.16	6.18 ± 0.27	6.04 ± 0.34
FI (%)	14.82 ± 1.18	13.14 ± 3.29	14.09 ± 3.03
Yo-Yo IR2 (m)	400.00 ± 74.48	447.50 ± 85.44[a]	490.00 ± 75.19[b]

ANOVA *one-way* was used to assess differences between variables, followed by post hoc Bonferroni.
 [a] Statistical difference between T1 and T2 ($p \leq 0.05$).
 [b] Statistical difference between T1 and T3 ($p \leq 0.05$).
 [c] Statistical difference between T2 and T3 ($p \leq 0.05$).

Results

Performance indicators

The study evaluated different performance indicators and analyzed the correlation of physical capacities intra and intersystems at different times of the season. The athletes performed regular training, as presented in Table 1, and were assessed in three moments during the season by performance tests which resulted in different indicators, separated into the functional and the neuromuscular groups (Table 2).

Table 3 presents the results of performance indicators (mean ± standard deviation) for the three assessment moments.

It was noticed that the variables of which manifestations are predominantly in the neuromuscular group behave differently. It is possible to observe that the CMJ indicator, although not presenting significant difference between the assessment moments, suggests a slight value reduction from T1 to T3 ($p > 0.05$). For 10 m, the opposite is observed, as a slight increase in these values is presented throughout the three moments, although with no significant difference ($p > 0.05$).

In relation to 30 m, there was a significant reduction in this indicator performance from T1 to T2 and between T1 and T3 ($p \leq 0.05$), while the same statistical behavior occurred for the MaxSprint mean values ($p \leq 0.05$).

Functional predominance performance indicators presented reductions in mean values from T1 to T3 for MidSprint, and were significantly confirmed between T1 and T3 and between T2 and T3 ($p \leq 0.05$). MinSprint and FI did not present significant differences in different times ($p > 0.05$). On the other hand, it is noticed that there was an increase in the Yo-Yo IR2 values, which presented increase from T1 to T3, and significant from T1 to T2 and from T1 to T3 ($p \leq 0.05$).

The results of the performance indicators and their changes presented in the three assessment moments can indicate correlation variations throughout the season, according to the physical capacities adaptations (Table 3), which are influenced by the adopted training programs (Table 1).

Intra-system correlation

Table 4 presents the correlations of indicators of neuromuscular physical capacities intra-system, which allowed the verification of strong positive correlation between 30 m and MaxSprint in T1 ($r = 0.93$, $p \leq 0.001$), with a correlation value reduction in T2 and T3. The CMJ and 10 m indicators did not present significant correlation with other neuromuscular system indicators ($p > 0.001$).

The correlations of the functional system indicators are shown in Table 5 and present positive correlation between MidSprint and MinSprint in T1, T2 and T3 ($r = 0.95$; 0.85; 0.91,

Table 4 Pearson correlation values between neuromuscular performance indicators in each assessment moment:.

	CMJ			10 m			30 m		
	T1	T2	T3	T1	T2	T3	T1	T2	T3
CMJ	–	–	–	–	–	–	–	–	–
10 m	−0.06	0.45	0.32	–	–	–	–	–	–
30 m	0.66	0.60	0.51	−0.34	0.49	0.41	–	–	–
MaxSprint	0.62	0.53	0.50	−0.38	0.35	0.17	0.93[a]	0.73	0.74

Pearson correlation was used to verify the relations between the analyzed variables.
 [a] Statistical difference ($p \leq 0.001$).

Table 5   Pearson correlation values between functional performance indicators in each assessment moment.

	MidSprint			MinSprint			FI		
	T1	T2	T3	T1	T2	T3	T1	T2	T3
MidSprint	–	–	–	–	–	–	–	–	–
MinSprint	0.95[a]	0.85[a]	0.91[a]	–	–	–	–	–	–
FI	0.06	−0.23	−0.61	−0.22	−0.67	−0.86[a]	–	–	–
Yo-Yo IR2	0.51	0.62	0.69	0.60	0.61	0.67	−0.31	−0.33	−0.44

The Pearson correlation was used to verify the relations between the analyzed variables.
[a] Statistical difference ($p \leq 0.001$).

Table 6   Pearson correlation values between functional and neuromuscular performance indicators in each assessment moment.

	CMJ			10 m			30 m			MaxSprint		
	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3
MidSprint	0.60	0.38	0.40	−0.35	0.61	0.32	0.95[a]	0.67	0.50	0.96[a]	0.84[a]	0.81
MinSprint	0.54	0.21	0.31	−0.35	0.64	0.31	0.93[a]	0.40	0.22	0.87[a]	0.54	0.59
FI	0.19	0.23	−0.06	−0.08	−0.43	−0.28	0.04	0.18	0.20	0.30	0.26	−0.09
Yo-Yo IR2	−0.07	−0.04	0.19	−0.08	0.30	0.36	0.39	0.30	0.48	0.42	0.42	0.60

The Pearson correlation was used to verify the relations between the analyzed variables.
[a] Statistical difference ($p \leq 0.001$).

$p \leq 0.001$, respectively), and negative correlation between MidSprint and FI in T3 ($r = -0.86$, $p \leq 0.001$), increasing the proportion progressively in T1 and T2. The other indicators did not present significant correlation.

Intersystem correlation

Table 6 presents the correlation between the indicators of the functional and neuromuscular groups. It was possible to observe strong correlation between 30 m and MidSprint in T1 ($r = 0.95$, $p \leq 0.001$); 30 m and MinSprint in T1 ($r = 0.93$, $p \leq 0.001$); MaxSprint and MidSprint in T1 and T2 ($r = 0.96$; 0.84, $p \leq 0.001$, respectively), and MaxSprint and MinSprint in T1 ($r = 0.87$, $p \leq 0.001$), noticing that the proportion was progressively reduced during the season.

Discussion

The purpose of this analysis was to point out the existence of interdependence or response heterochrony of performance indicators of different physical capacities during the studied training period and, at the same time, to highlight changes in the correlations considering the training content. According to what was observed, the indicators change to the extent that the stimuli are applied and, consequently, the correlations between the indicators also change.

The results showed that functional and neuromuscular capacities were related at the beginning of the season. Over time such relation decreased, which can be derived from the functional training prevalence, especially the specific resistance (Table 1), and this predominance may have influenced physical capacities with neuromuscular characteristics which, consequently, caused the correlation decrease.

Particularly in relation to the predominantly neuromuscular capacities, their training volume and frequency were below the level recommended by Gomes and Souza (2008), since, due to the importance of neuromuscular capacities performance for soccer players, the percentage of this training must be similar to the functional one, or even bigger, in some moments. The results of the applied content can be seen in the neuromuscular indicators, in which only a slight improvement in 10 m could be verified, although with no statistical evidence, while other indicators from the same group presented a slight decrease (such as CMJ) or even significant decrease, as observed in 30 m and MaxSprint (Table 3). Although the training content is not the main focus of this study, the fact that it seems to have the most influence on the adaptive responses for the assessed performance indicators cannot be neglected.

Coelho *et al.* (2011) analyzed the correlation degrees between neuromuscular performance indicators (speed at 10 m – V10, speed in the last 20 m of the test at 30 m – V20, speed at 30 m – V30 and vertical jump with countermovement – CMJ) in junior and professional soccer players and found weak to moderate correlations, and when considering moderate values for professional soccer players in the V10 indicators and CMJ ($r = 0.381$, $p < 0.05$), this response was considered to be linked to the specific content of the training program conducted at that moment by the professional staff.

The correlations values between the neuromuscular indicators associated with training content raise important issues. The main one is about the highest correlation values between indicators, which partly occur in T1. After the training influence, changes in the indicators are observed, which suggests that the correlation between the physical capacities may vary due to the lack of stimulation for some and stimulation priority for others. It must be clear that

those changes cannot be attributed only to the training content, since previous studies pointed to the specificities of the speed capability manifestations (Little and Williams, 2005). However, in case the training of all manifestations were kept in satisfactory levels and used appropriate and effective means and methods for each proposal, the correlation levels would possibly remain unchanged. It is important to point out that a significant correlation between 30 m and MaxSprint in T1 was observed, which is not repeated in other moments. Such data confirms the similarities in speed manifestations at the beginning of the studied period, as both assessed capacities use very similar stimuli but, due to the content characteristics, this level was not maintained, showing that one of them was more influenced than the other during the training throughout the season.

Some studies present high correlation levels between jump and short-distance high-intensity sprints (Wisloff et al., 2004; Chelly et al., 2010), which is opposed to the presented findings, since CMJ and 10 m presented low correlation levels. This can be possibly explained by the inexistence of positive adaptive responses provided by the training focused on strength and speed.

Regarding training content and its influence in indicators of physical capacities with functional predominance, these presented improvement, which is observed in all indicators from this group. However, as previously shown, the high percentage of time directed to the functional system is due to the high percentage of specific resistance training, indicated by Yo-Yo IR2, which presents significant improvement throughout the assessment moments. This is not consonant with the other indicators with the same predominance that are more directly related to speed endurance manifestations.

The correlation data presented in Table 5 do not present significant correlation between Yo-Yo IR2 and other functional indicators in the different moments, showing that even though they present the same predominance, speed endurance and specific endurance have particularities that must be respected, both for the specificity and recurrence in the sport (Buchheit et al., 2010) and the methodology for the training sessions development (Ferrari Bravo et al., 2007; Sporis et al., 2008; Meckel et al., 2009).

It was possible to confirm that the applied content does not provide positive adaptation effects on performance, for the lack of improvement of these indicators and for the significant correlation between MidSprint and MinSprint in the three moments, evidencing that the reduction in the speed mean values in RAST is directly associated to the lowest speed mean in the test, indicating a decrease in speed endurance performance. The strong negative correlation between MinSprint and FI demonstrates that, when developing and applying training programs, they can lead to a decrease in the values of the speed lowest mean in RAST (MinSprint). Consequently, there is an increase in the percentage of fall values of speed in the same test (FI), showing a drop in speed endurance levels. Such fact is evidenced, while it is possible to observe a low percentage of time devoted to stimuli for the speed endurance development and, when neglecting certain training methods characteristics, capacity level indicators are not maintained and alter all potentialities of such specific capacity, as well as of other which could be positively influenced.

Some previous studies sought to correlate functional and neuromuscular indicators. Souza et al. (2012) analyzed the relation of neuromuscular indicators (countermovement vertical jump, horizontal jump and agility) with functional indicators provided by RAST, but no significant correlation was found. It was concluded then that the functional performance assessed by RAST does not exclusively depend on neuromuscular performance, since previous studies reported that RAST is a test of anaerobic metabolism prevalence.

However, when correlating functional and neuromuscular indicators in the three season moments (Table 6), four significant correlations are presented in T1 (30 m and MidSprint; 30 m and MinSprint; MaxSprint and MidSprint; MaxSprint and MinSprint), one in T2 (MaxSprint and MidSprint) and none in T3.

It is observed that, initially, indicators presented satisfactory correlation levels and, as the training program was developed and applied, there was a variation and decrease of the initial levels, which raises two important issues: (i) when providing unilateral and specific stimuli to a physical system or capacity, the correlation levels may decrease as a consequence of the unilateral adaptations with focus on the trained system; (ii) when considering the stimuli of a multifaceted training, in which the possibility of improvement of all important capacities for soccer playing performance are equally approached, two correlation behaviors can be considered – the first, regarding the maintenance of the initial levels throughout the training program, and the second, in relation to the presence of even lower correlation levels, being even negative when associating a functional and a neuromuscular indicator, due to the training specificities and to the heterochrony of adaptive responses to the applied stimulus. In this respect, it is the role of the professional responsible for the training content, organization and performance, to observe the behavior and correlations on the performance indicators, in order to verify whether the expected changes in important physical capacities are or are not occurring.

The different physical capacities presented different relations according to different season moments. The finding will help coaches and physical trainers throughout the organization and structuring of the training programs, showing that physical capacity responses react according to the training organization. That is, they must be trained in a specific way with appropriate time, means and methods to each one of them, either in positive and in negative ways so that, at last, each one of them will be predominant in the training content in their proper time and, thus, there will be performance improvement and changes in correlations.

This is one of the first studies to present the correlation of performance indicators and training content throughout a sports season, showing how they react to training and its organization over time. The presented results can also benefit other sports modalities, both team and individual, which follow the same principles. For more significant advances, future research can evaluate and search to correlate indicators of physical capacities performance in specific tests, as well as those verified and measured during the competitive activity.

Conclusion

Through the analysis of neuromuscular and functional intra and intersystem correlations, behavior patterns are not observed, which indicates that physical capacities are ruled by specificities that must be considered in the training content. In that sense, it is also important to point out that, when prioritizing only one system and directing part of the stimuli to one capacity, as occurred with specific endurance, even those with similar predominance (functional) may present decrease and not be benefited by the performance improvement, which is the case of speed endurance.

The contents seem to have real relation with what was found in the values and changes in the two systems' indicators (neuromuscular and functional). Thus, even when considering that, in this study, the focus was not on the training contents but on understanding which performance indicators are influenced by stimuli that promote specific morphofunctional adaptations in each organic system, it is possible to conclude that performance indicators change as a response to training and its organization and, therefore, the use of such indicators and their correlation serve as guides for monitoring the organization of training sessions and periods, and also as tools for checking whether the training program is promoting the necessary adaptations of physical capacities and systems and whether the correlations between indicators that optimize one another are related in planned and necessary ways.

Conflicts of interest

The authors declare no conflicts of interest.

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