Universidade de Trás-os-Montes e Alto Douro

The effects of a reaction time and eye-hand coordination training in youth players

Dissertação de Mestrado Internacional em Análise da Performance Desportiva

Márcio André Araújo Carvalho

Orientador: Professor Doutor Nuno Miguel Correia Leite

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Declaro que esta dissertação de mestrado é o resultado de uma pesquisa e trabalho pessoal efetuada por mim e orientada pelo meu supervisor. O seu conteúdo é original e todas as fontes consultadas estão devidamente citadas no texto e mencionadas na bibliografia final. Declaro ainda que este trabalho não foi apresentado em nenhuma outra instituição para a obtenção de qualquer grau académico.

Vila Real, Outubro de 2017

Márcio André Araújo Carvalho

“Ever tried. Ever failed. No matter.

Try again. Fail again. Fail Batter”

– Samuel Beckett –

Agradecimentos

Em primeiro lugar agradeço à família… a base de uma pirâmide tão alta! É a eles que devo tudo! O maior pilar e, para eles, o meu maior agradecimento… os meus pais! São constantemente o melhor dos exemplos a seguir, sempre me proporcionaram todas as condições necessárias para eu abraçar um futuro melhor, me apoiaram em todas as decisões que tomei e encorajaram a dar um passo em frente e sair da minha zona de conforto. À minha irmã, por me obrigar todos os dias a ser uma melhor pessoa, a ganhar responsabilidade e a crescer enquanto pessoa e, aos restantes, um especial agradecimento por terem sempre feito de mim uma pessoa melhor e com o maior orgulho nas suas origens.

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Ao meu orientador, professor Nuno Leite, por me ter colocado perante a possibilidade de abraçar um projeto tão ambicioso e desafiante como este mestrado e que tanto contribuiu para o meu crescimento. Finalmente, e particularmente dirigido a esta fase final, fica o meu maior agradecimento ao mestre Nuno Mateus, por garantir sempre toda a ajuda necessária e por ter sido uma peça fundamental no desenrolar de todo o processo!

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Resumo

Formas alternativas para desenvolver o potencial dos atletas, como o treino da velocidade de reação (RT) e da coordenação óculo-manual (EHC) têm aumentado nos últimos anos, com o objetivo de alcançar novos e, cada vez mais elevados, níveis de performance. O objetivo deste estudo foi avaliar a eficácia de um programa de treino de velocidade de reação e de coordenação óculo-manual em diferentes parâmetros de desempenho físico de jovens atletas. Vinte e dois atletas (11-17 anos de idade) com diferentes proveniências desportivas foram divididos em dois grupos, grupo experimental (EG, n = 11) e grupo controlo (CG, n = 11). Durante um período de 12 semanas, os atletas de ambos os grupos mantiveram os seus planos de treino habituais, no entanto, aos atletas do grupo experimental foram adicionadas duas sessões de treino de RT e EHC com duração de 15 minutos cada uma. Qualidades físicas como o equilíbrio dinâmico dos atletas, velocidade do movimento dos membros superiores, agilidade, agilidade reativa, a aceleração e a velocidade de corrida foram avaliadas antes e depois do programa experimental ter sido posto em prática. Após o período experimental, *melhorias prováveis* foram verificadas no teste de velocidade dos membros superiores (EG, tamanho do efeito [ES]: -6,0; ± 5,8; CG, ES: -3,9; ± 4,2) em ambos os grupos. Para além disso, o EG também mostrou *prováveis melhorias* nos 10 metros iniciais do teste de *sprint* (ES: -2,6; ± 2,5) e *melhorias prováveis* na capacidade de equilíbrio dos atletas (direção anterior (perna direita, ES: 5.4; ±4.3; perna esquerda, ES: 4.0; ±3.5); direção posteromedial (perna direita, ES: 6.6; ±2.1; perna esquerda, ES: 8.0; ±3.1; e direção posterolateral (perna direita, ES: 10.7; ±4.2; perna esquerda, ES: 14.6; ±5.0). Assim, este programa de 12 semanas de treino levou a melhorias significativas na velocidade de aceleração e nas capacidades de equilíbrio dinâmico de jovens atletas com diferentes antecedentes desportivos. Neste contexto, os treinadores de atletas jovens podem usar esta metodologia de treino para reduzir o risco de lesões e obter ganhos importantes na performance dos seus atletas.

Palavras-chave: Velocidade de Reação; Coordenação Óculo-manual; Capacidades Desportivas; Jovens Atletas

Abstract

Alternative ways to develop athletes' potential, such as Reaction Time (RT) and Eye-Hand Coordination (EHC) training has been increasing in recent years, with the aim to achieve new performance levels. The purpose of this study was to evaluate the effectiveness of a reaction time and eye-hand coordination training program on different physical performance parameters of young athletes. Twenty-two athletes (11–17 years old) from a different sport background were assigned into an experimental group (EG, n = 11) and a control group (CG, n = 11). Over a 12-week period, both groups continued their usual specific training, but the EG added twice-weekly 15-minutes of RT and EHC training sessions. All players' dynamic balance, limb movement velocity, agility, reactive agility, acceleration and running speed were assessed before and after the experimental program. Following the training, *likely* improvements in plate taping (EG, effect size [ES]: -6.0; ±5.8; CG, ES: -3.9; ±4.2) were found in both groups in comparison to pre-test results. In addition, EG also showed likely enhancements in the 10-m sprint test (ES: -2.6; ±2.5), and a *likely* and *most* likely improvements in balance capacity (anterior direction (right leg, ES: 5.4; ±4.3; left leg, ES: 4.0; ±3.5); posteromedial direction (right-leg, ES: 6.6; ±2.1; left-leg, ES: 8.0; ±3.1; and posterolateral direction (right-leg, ES: 10.7; ±4.2, moderate; left-leg, ES: 14.6; ±5.0, large)). Therefore, 12-week of RT and EHC training lead to meaningful improvements in acceleration speed and dynamic balance capacities of young athletes with a different sport background. In this context, youth sport coaches can use these training methodologies to reduce the risk of injury and elicit important performance gains on their athletes.

Keywords: Reaction Time; Eye-Hand Coordination; Sport Capacities; Young Athletes

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List of Abbreviations

Ant – Anterior

CG – Control Group

CL – Confidence Level

CNS – Central Nervous System

EF – Effect Size

EG – Experimental Group

EHC – Eye-Hand Coordination

L – Left

PHV - Peak Height Velocity

Pl – Posterolateral

Pm – Posteromedial

R – Right

RT – Reaction Time

SD – Standard Deviation

YB – Y Balance Test

Introduction

Since the path to sporting excellence in elite sport is increasingly demanding (De Bosscher, De Knop, Van Bottenburg, and Shibli, 2006), several world sporting organizations started to explore alternative training approaches to athletes take advantage over their opponents, in an increasingly early age (Bergeron et al., 2015). This conjuncture led to a tremendous growth in the demand of promising strategies to improve the athletes' capacities, arising the emergence of several companies, scientific equipment and modern facilities, focused in a more specific and detailed training to develop exceptional athletes (Fort et al., 2012; Rhea et al., 2008; Rees, 2016).

Most of motor skills required at elite sports level are developed across the lifespan. However, there are sensitive periods of optimal trainability – "windows of accelerated adaptation to training" (Balyi, Way, Norris, Cardinal & Higgs, 2005) – where younger athletes are individually more susceptible to react and adapt to specific training stimulus (Balyi et al., 2005). It is expected, that immediately before the onset of the growth spurt, a young athlete that trains with the aim of reach an elite level, own a repertoire of basic motor skills and developed crucial physical abilities (e.g., agility, speed, power and strength) that will be the cornerstones of all athletic development (Lloyd & Oliver, 2012; Balyi & Hamilton, 2004) and enhance the probability of develop a future talent (Calero, 2013), considering their profound impact on future sport performances. Furthermore, these different abilities assume an important requirement in any person's daily life.

With the widely growing effort of new and relevant researches to find alternative ways to develop the human movement control and create new training methods, the importance that has been given to the training of natural abilities such as eye-hand coordination (EHC) (Faber et al., 2014; Yuan et al., 1995; Zetou et al., 2012) and reaction time (RT) (Ceylan & Saygin, 2015) has been exponentially increasing. EHC was been previously mentioned to the guidance of actions by perceptual information, and is regarded as a key contributor to success in visual abilities, postural balance and in specific interceptive aiming sports (Ellison, 2015). Furthermore, it can be influenced by various factors such as age, gender, stimulus, tiredness, and physical activity (Ashnagar et al., 2015). On the other hand, RT has been described as the process of transformations and time, through which information passes through the nervous system, translating the speed with which the subject treats the information and start a predetermined response (Alves, 1995). Expressed in sport context is the quickness of an athlete to respond to some sort of stimulus (Pain & Hibbs, 2007) and is especially important in individual and team sports in which the motor-manipulative skills are quite used, and in the sports in which rackets are used because of the high sensitivity and rough muscle control requirement (Menevse, 2011).

EHC and RE together are assumed as preponderant qualities in sport environment, especially when the performance depend of players' abilities to see and react to game constraints, i.e., avoiding a defender or intercept the path of a ball (Lennemann et al., 2013; Ellison, 2015). These capacities are particularly important in sports that require exalted passing, throwing, catching or hitting skills, such as table tennis (Rodrigues, Vickers & Williams, 2002), handball (Dane & Erzurumluoglu, 2003), combat sports (Mori, Ohtani & Imanaka, 2002), baseball and cricket (McLeod, 1987).

Despite their importance, to the best of our knowledge, no previous studies had evaluated its effects on different motor capacities of youth athletes, with a different sport background. Therefore, the purpose of this study was to assess the effectiveness of a reaction time and eye-hand coordination-training program on different performance capacities related to youth sports.

Methods

Experimental Approach to the problem

To determine whether long-lasting effects of a reaction time and eye-hand coordination training in different sport performance capabilities of trained young subjects, a 12-week RT and EHC training protocol, using the *Batak Pro™*, was added to the normal training exercises of a group of athletes. Twenty-two subjects of different ages were selected from various sports and were divided into two different groups, forming the experimental (EG) and control group (CG). EG was composed by athletes belonging to Talentódromo. In order to guarantee the validity of the results, isolating other possible training effects, CG was formed with one peer of each EG subject, that means, an athlete of the same team (with the same training routine), with body characteristics as similar as possible and with identical sport experience. Both groups performed the regular training sessions, the only difference was the implementation of 2 fifteen-minute's sessions of RT and EHC training per week (approximately) to the experimental group, during twelve weeks, in a total of 24 intervention, between March and June.

Data were collected at 2 time point during the study: before the starting of the training program (T1) and at the end of the 12-weeks training protocol (T2). Different assessment tests were used to evaluate the participants. The protocol included: Y Balance Test to measure participant's dynamic balance, Plate Tapping Test to assess velocity and coordination of limb, 5-0-5 Agility Test to evaluate agility performances, Reactive Agility Test to assess the reaction time to a stimulus during an agility task and the 10-30m Sprint Test to measure acceleration and running speed.

Subjects

Twenty-two young athletes, (18 male, 4 female) (age, 13.8 ± 1.7 years old; weight, 55.6 ± 10.2 kg; height, 164.2 ± 12.6 cm) were recruited to participate in this study (Table 1). Inclusion criteria were young athletes (aged 11 to 17 years) with, at least, three years of competitive experience in their specialization sport. The subjects were assigned to the EG and CG. The EG subjects were randomly chosen among members of TALENTODROME PROGRAM and, in order to guarantee the validity of the results, CG was composed by one peer of each EG subject (an athlete with the same training routine, with similar anthropometric and body-weight characteristics, as well as identical sport experience). Participants, their legal guardians and their coaches received detailed written and verbal information about the possible risks and discomfort associated with testing and training, and provided written informed consent before the study started. The study protocol was conducted in accordance with the Declaration of Helsinki, and was approved and followed the guidelines stated by the local Institutional Research Ethics Committee.

Before the study started, participants and their parents received detailed written and verbal information about the possible risks and discomfort associated with testing and training. Written informed consent was obtained from participants and also from parents in view of the athletes' ages.

Table 1. Mean (±SD) of body height, weight, and age of the sample.

Anthropometric data	EG (n=11) (mean ± SD)	CG (n=11) (mean ± SD)
Height (cm)	163.8 ± 10.9	164.7 ± 14.8
Weight (kg)	55.7 ± 10.3	55.6 ± 10.7
Age (years)	14 ± 1.7	13.6 ± 1.8

EG = experimental group; CG = control group.

Procedures

Testing Protocols

To evaluate the different purposes of the study, the sample executed a set of physical/fitness tests in two different moments: two days before the beginning of the protocol and two days once the end. All the test were executed in the same day, at same time and under the same conditions. Participants were advised to not perform any strenuous activity in the 24 hours preceding the tests and to not consume their last meal at least 2 hours before testing.

One week previously to testing, there was a previous familiarization with the testing equipment and procedures. On testing days, subjects accomplished a 15-minute warm-up protocol – FIFA 11+, that requires no equipment other than a ball, and comprised evidence-based exercises that improve physical performance and reduce the injury risk (Ayala et al., 2017; Steffen et al., 2013).

Y Balance Test

The lower extremity balance and neuromuscular control was assessed using Y Balance Test (YB). To minimize the influence of a learning effect each participant viewed an instructional video of the test and performed six practice trials before the assessment. As explained in previous studies (Plisky et al., 2009), after the instructional video, participants stood on the centre footplate, with the distal aspect of the right foot at the starting line. While maintaining single leg stance on the right leg, the subject reached with the free limb in the anterior, posteromedial and posterolateral directions in relation to the stance foot by pushing the indicator box as far as possible. Participants completed three consecutive trials for each reach direction and in order to reduce fatigue between trials they were allowed to alter limbs between each direction. Specifically, testing order was completed as right anterior, left anterior, right posteromedial, left posteromedial, right posterolateral, and left posterolateral. The trials were invalid, if the subjects failed to maintain unilateral stance on the platform, were not able to maintain reach foot contact with the reach indicator on the target area, while it is on motion, used the reach indicator for stance support or unsuccessful return the reach foot to the starting position under control.

Plate Tapping Test

Speed and coordination of limb movement (plate tapping) was recorded with a reaction test that is based on an alternating wall tapping action, measuring upper body reaction time, eye-hand quickness and coordination. Identical to previous studies (Oja & Tuxworth, 1995), one custom table on which two discs at 80 cm distance and a rectangle placed equidistant between both discs was used for the evaluation. The non-preferred hand was placed immobile on the rectangle while the preferred hand touches alternately the discs over the hand in the middle as quickly as possible. This action was repeated for 25 full cycles (50 taps). The time was measured using a stopwatch studies.

Reactive Agility Test

The reactive agility test has been described in detail elsewhere (Sheppard, Young, Doyle, Sheppard & Newton, 2006). In brief, the athlete began on the marked line. Performance time was recorded using electronic photocells (*Microgate*, Bolzano, Italy) as timing gates that were placed 5 m to the left and right and 2 m forward of the start line. Thus, the timing gates were placed 10 m from each other, forming a “gate” of 3 meters each. The tester (researcher) stood opposite, and facing, the participants. The investigator stood behind a “gate”. Each test trial involved the tester initiating movement, with an audible beep emitted by the photocells and thereby beginning the timing. The athlete reacted to the movements of the tester, forward, then to the left or right in response to, and in the same direction as, the left or right movement of the tester. The timing stopped when the athlete triggered the timing beam on either side.

The tester displayed one of four possible scenarios for the athlete to react to, however the athletes did not explicitly know this. The four possible scenarios all involved steps of approximately 1 m and were presented in a random order that was different for each athlete: i) step forward with right foot and change direction to the left; ii) step forward with the left foot and change direction to the right; iii) step forward with the right foot, then left, and change direction to the right; and iv) step forward with the left foot, then right, and change direction to the left.

There was an equal amount of each scenario for each participant. The test protocol involved randomised presentation of 4 different cues, for a total of 8 trials. These cues created varying demands on the participants (as in a game setting), resulting in inter-trial variability. For this reason, participants performed a total of 8 trials, with at least thirteen seconds of rest between them. The mean of all trials (8), which was an average of all trials to the left (4) and to the right (4) were recorded for the subsequent data analysis.

Each participant was instructed to recognise the cues as soon as possible (essentially while moving forward) and react by changing direction and sprinting through the gates on the left or right in response and were also instructed to emphasise accuracy (decision-making accuracy) and speed of movement.

5-0-5 Agility Test

The changing direction speed of players was evaluated using the 5-0-5 test, explained in previous studies (Ellis et al., 2000). In short, was measured using two electronic photocells (*Microgate*, Bolzano, Italy), at a height of 1 m placed 5 m from a designated turning point. The players were instructed to start each test from a line placed 0.3-m behind the start line. The starting line was placed 10 m from the timing gates (and therefore 15 m from the turning point).

Players were instructed to accelerate as quickly as possible through the timing gates, pivot on the 15 m line, and return as quickly as possible in direction to the timing gates. Two trials with at least two minutes of rest between them were recorded. Change of direction speed times were measured to the nearest 0.01 s with the fastest value obtained from two trials used as the change of direction speed score.

10-30m Sprint Test

Velocity and running speed were recorded using 30 m distances (with 10 m split time). Participants performed two 30-m sprints, with at least three minutes of rest between them. The fastest performance trial was recorded for the subsequent data analysis. During the recovery period between sprints, the subjects walked back to the starting line and then waited for their next trial. Performance time was recorded by using electronic photocells (*Microgate*, Bolzano, Italy) placed at the start, 10 and 30 meters from the starting line, at a height of 1 m. The athletes were instructed to start each sprint from a line placed 0.3-m behind the start line and timing started when they broke the light beam. Players were asked to run as quickly as possible through the final pair of sensors (Alemdaroğlu, 2012). For this test, 30 m was considered the maximum distance that could be used in the indoor facility to allow enough space to safely decelerate after the finish line (Young et al., 2008).

Reaction Time and Eye-Hand Coordination training

Subjects of experimental group performed the RT and EHC training interventions twice weekly, Reaction time and eye-hand coordination training was carried out on a *Batak Pro*™ (*Quotronics Ltd*, Surrey, United Kingdom) for a lasted period of twelve weeks. All sessions were executed after the warm-up and under the guidance of the researcher to guarantee correct execution of the tasks.

The training sessions involved different static and dynamic exercises, performed in fifteen minutes blocks, applied in different moments of the TALENTODROME training sessions, avoiding problems related with fatigue and athletes' predisposition to perform the task. During the protocol, only programs with duration equal or less than 60 seconds were used, and the training parameters were increased progressively in frequency, repetitions, training volume, recovery period between them and complexity of the exercises (e.g.: subjects can only use one hand, with one eye closed with an occlusion patch, etc.…). In order to guaranty an equivalent difficulty of exercises, the training sessions were previously planned, selecting the most appropriated programs to implement in all the participants. Thus, the programs (and description) used during the 12-weeks protocol were: *“Accumulator 30s”* – random targets lasting for 30 seconds and remain on until the user struck out and setting the pace to slow or fast speed; *"50 Timed Targets - 1 second targets”* – a total of 50 timed targets, with 1 second or strike opportunity, illuminate in succession and at random order, when the display counting them down and shows each successful strike; *"50 Targets Race”* – a total of 50 random targets to be reached as quickly as possible; *"4 Corner Stretch – 25/50 Targets”* – 25 or 50 corner only targets illuminate at random and remain on for 1 second; *"Batak Mirror Race”* – 50 random targets have to be reached as quickly as possible, however, the strikes must be the mirror image of the one illuminated to be successful and *"Snap Reaction Time - 6 Targets”* – a pure reaction time program, where the six chosen targets are randomly illuminated, starting the time counting. The target remains lit until struck out with the time taken being shown (*Batak*, 2017).

A training program was only considered valid when the subject completed at least 80% of the training sessions.

Statistical Analysis

Individual and mean changes of all the participants, from pre to post-test were graphically represented and the variation from the considered moments expressed in percentage variation (mean ± SD). To realize the possibly beneficial/harmful effects of the interventions on players' performance measures, the data were analysed with a specific spreadsheet for a post-only analysis (W. G. Hopkins, 2007). The effects were estimated in percent units through log-transformation to reduce the non-uniformity of error and uncertainty in the estimate was expressed as 90% confidence limits.The outcome for performance measures was evaluated with the non-clinical version of magnitude-based inferences: suggested default probabilities for declaring an effect clinically beneficial are <0.5% (most unlikely) for harm and >25% (possibly) for benefit; a clinically unclear effect is therefore possibly beneficial (>25%) with an unacceptable risk of harm (>0.5%) (Hopkins, Marshall, Batterham & Hanin, 2009). Probabilities were reported using the following scale: 25–75%, possibly; 75–95%, likely; 95–99.5%, very likely; >99.5%, most likely. Standardized (Cohen) mean differences, and respective 90% confidence intervals were also computed as magnitude of observed effects, and, thresholds were: <0.2, trivial; 0.2-0.6, small; 0.61-1.2, moderate; 1.21-2.0, large; and >2.0, very large. Differences were defined as unclear when the confidence limits for the effect size include both substantial positive and negative values (±0.2*standardisation) (Hopkins et al., 2009).

Results

Individual and mean changes throughout the different assessment moments are illustrated in Figure 1. Complementary, Table 2 and Figure 2 shows the standardized differences, relative changes and practical inferences, respectively, based on the post-only analysis. Both groups shows a *likely improvement* (EG, effect size [ES]: -6.0; ±5.8, small; CG: ES: -3.9; ±4.2, small) on plate tapping test between pre and post-test. Moreover, EG also improved *likely* (ES: -2.6; ±2.5, small) in the 10-m sprint test. Regarding the Y Balance test, EG results showed a *likely improvement* in anterior direction, more precisely in the right leg (ES: 5.4; ±4.3, moderate) and left leg (ES: 4.0; ±3.5, small). EG also improved *most likely* in the posteromedial (right-leg, ES: 6.6; ±2.1, small; left-leg, ES: 8.0; ±3.1, moderate) and in posterolateral directions (right-leg, ES: 10.7; ±4.2, moderate; left-leg, ES: 14.6; ±5.0, large). On the other hand, CG improved *likely* for right-leg in anterior direction (ES: 5.2; ±4.2, small), right leg posteromedial direction (ES: 7.2; ±7.6, small) and left leg in posterolateral direction (ES: 6.0; ±6.5, small); and *very likely* improved for left leg in posteromedial direction (ES: 5.7; ±3.4, moderate) and for right leg in posterolateral direction (ES: 6.2; ±3.5, small).

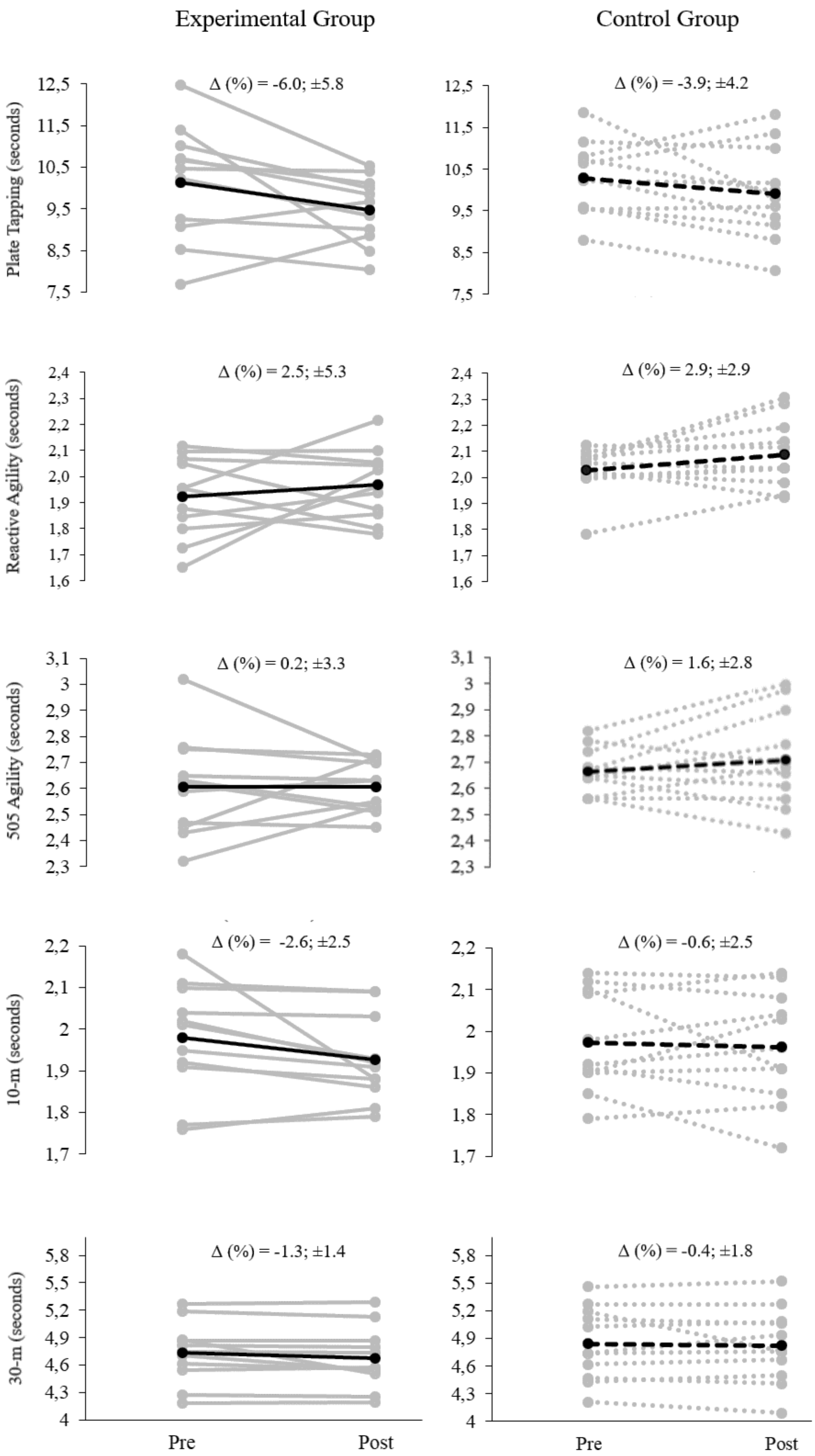

***Figure 1.* Individual and mean changes from pre to post-test for Plate Tapping, Reactive Agility, 5-0-5, 10-m and 30-m sprint tests.** Percentage variations (Δ %) are expressed as mean ± std. Black lines represents the group mean changes while grey represents individual changes.

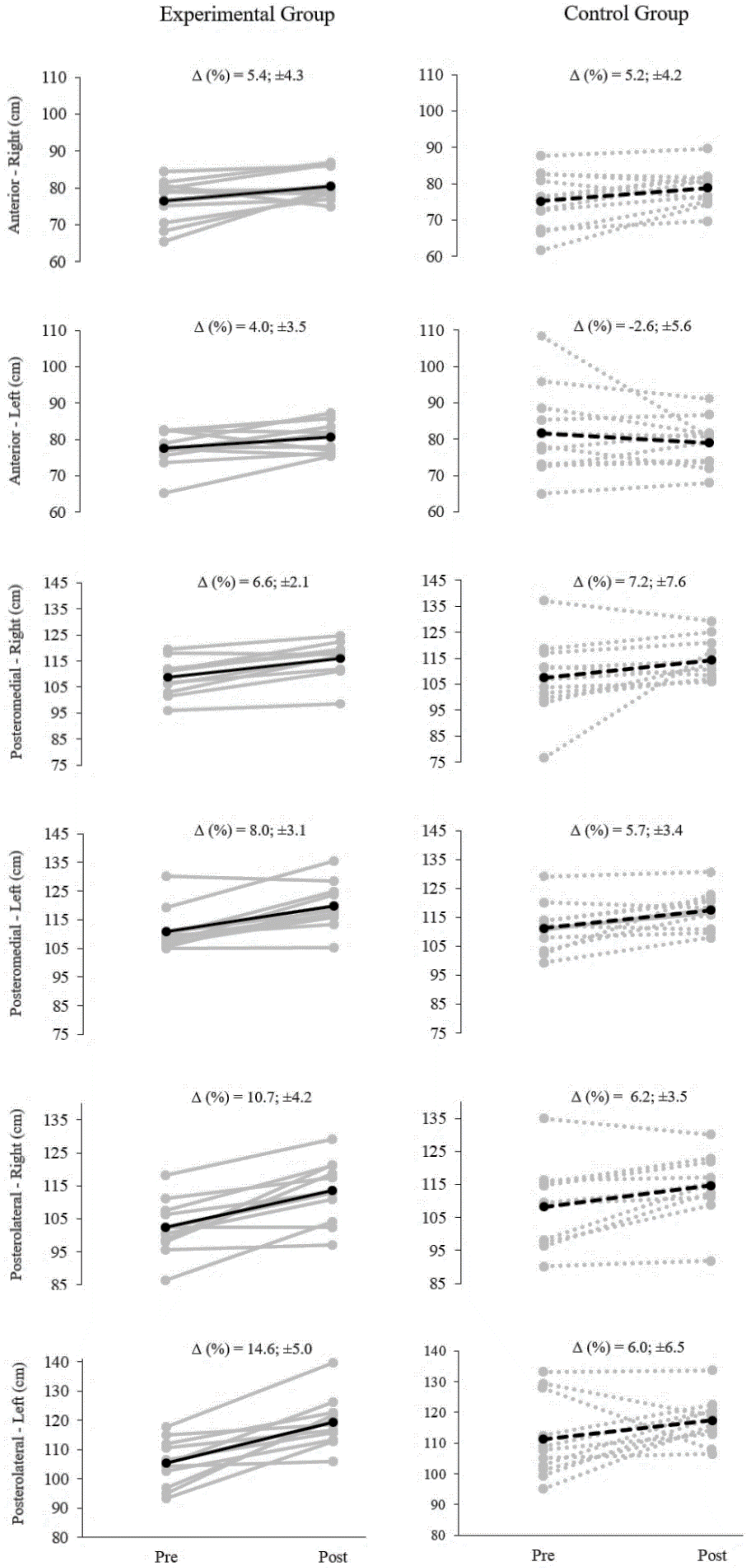

Figure 2. **Individual and mean changes from pre to post-test for Y Balance test (YB) in anterior (Ant), posteromedial (Pm) and posterolateral (Pl) directions to right (R) and left (L) sides.** Percentage variations (Δ %) are expressed as mean±std. Black lines represents the group mean changes while grey represents individual changes.

Table 2. Inferences of the training programs intervention on player's performance measures

Pre-Test – Post-Test						
Variables				Difference in means (%; ± 90% CL)	% Chances (harmful/trivial/improve)	Practical inferences
Plate Tapping			EG	-6.0; ±5.8	1 / 16 / 82	likely
			CG	-3.9; ±4.2	2 / 17 / 81	likely
Reactive			EG	2.5; ±5.3	61 / 30 / 9	unclear
			CG	2.9; ±2.9	88 / 10 / 2	very unlikely
5-0-5 Agility			EG	0.2; ±3.3	25 / 56 / 19	unclear
			CG	1.6; ±2.8	72 / 20 / 9	unclear
10-m Sprint			EG	-2.6; ±2.5	1 / 19 / 80	likely
			CG	-0.6; ±2.5	12 / 56 / 32	unclear
30-m Sprint			EG	-1.3; ±1.4	0 / 58 / 42	possibly
			CG	-0.4; ±1.8	3 / 85 / 12	likely
Y Balance	Anterior	Right	EG	5.4; ±4.3	1 / 6/ 94	likely
			CG	5.2; ±4.2	0 / 10 / 89	likely
		Left	EG	4.0; ±3.5	1 / 9 / 90	likely
			CG	-2.6; ±5.6	47 / 48 / 5	unclear
	Postero-medial	Right	EG	6.6; ±2.1	0 / 0 / 100	most likely
			CG	7.2; ±7.6	1 / 15 / 84	likely
		Left	EG	8.0; ±3.1	0 / 0 / 100	most likely
			CG	5.7; ±3.4	0 / 2 / 98	very likely
	Postero-lateral	Right	EG	10.7; ±4.2	0 / 0 / 100	most likely
			CG	6.2; ±3.5	0 / 3 / 97	very likely
		Left	EG	14.6; ±5.0	0 / 0 / 100	most likely
			CG	6.0; ±6.5	2 / 14 / 84	likely

Note: 90% CL - 90% Confidence Limits; EG - Experimental Group; CG - Control Group.

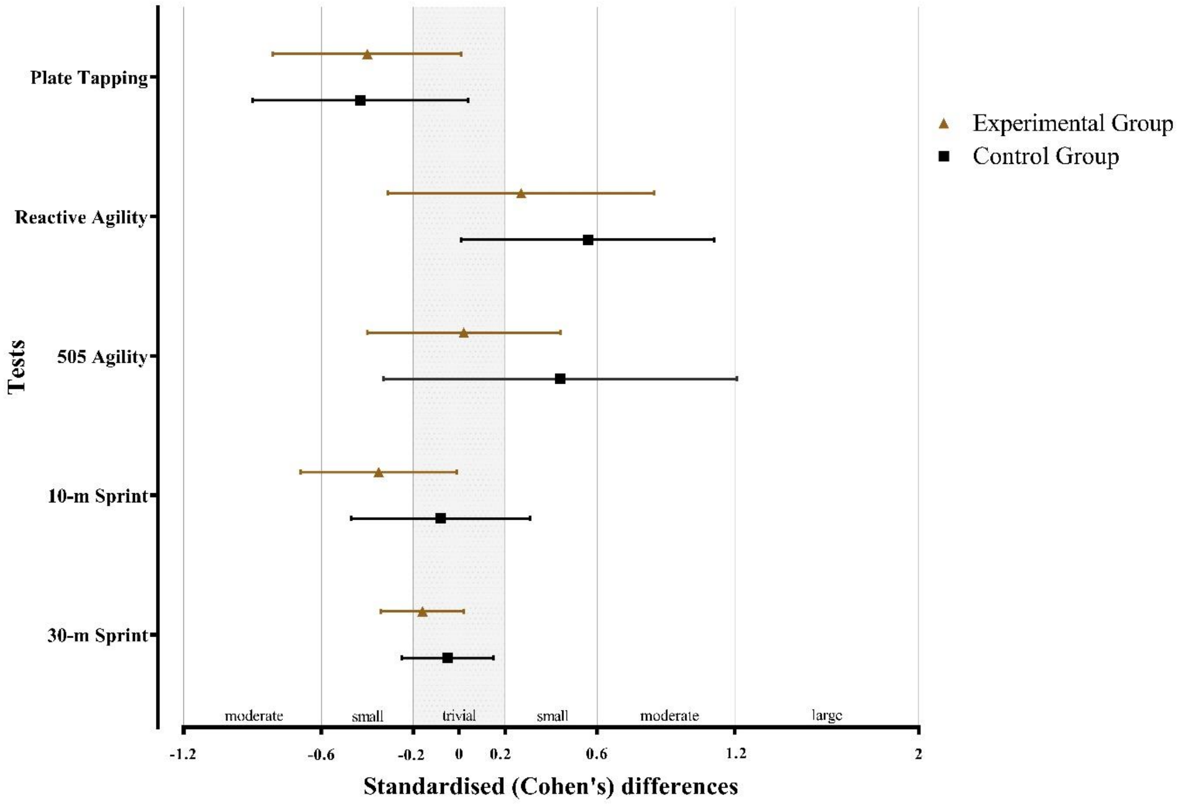

Figure 3. **Standardised Cohen's differences for Plate Tapping, Reactive Agility, 5-0-5, 10-m and 30-m sprint.** Error bars indicate uncertainty in true mean changes with 90% confidence intervals. Note: since lower values in protocols measured by time are related with better performance, all the above outcomes were changed from negative to positive, and vice-versa. This decision was made for a better interpretation of the results.

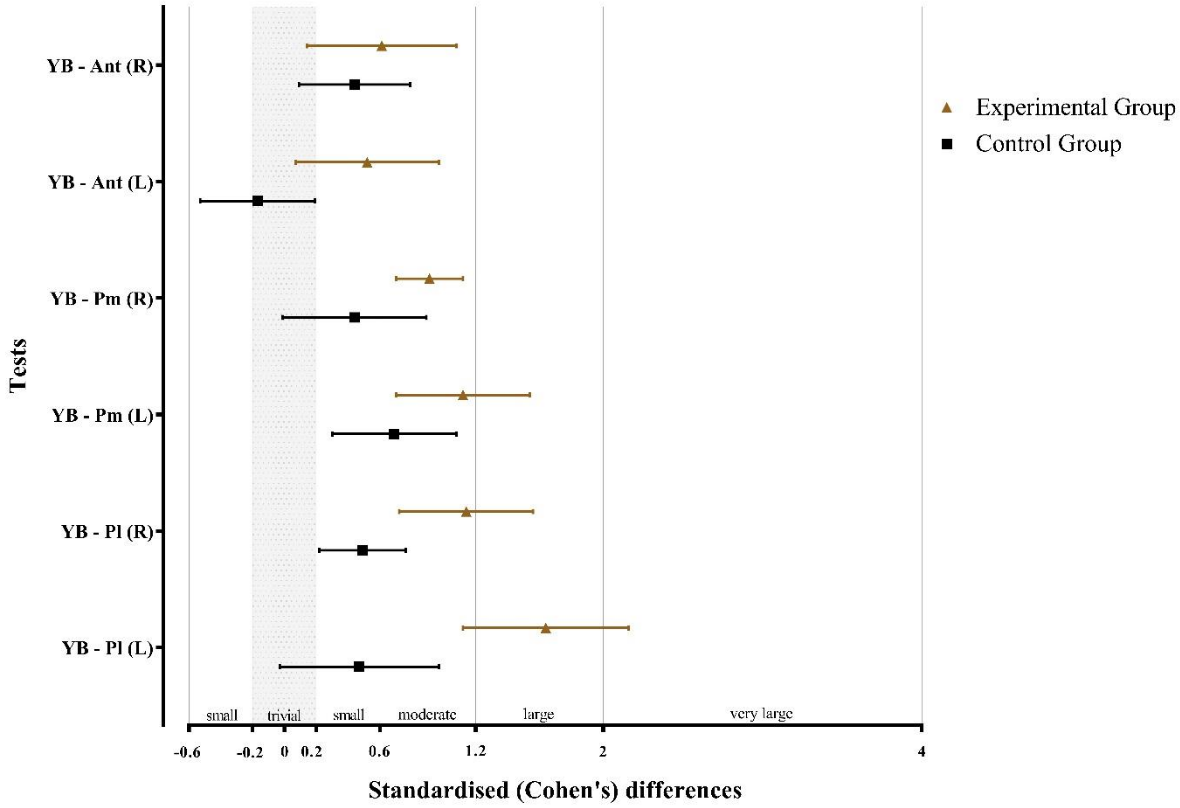

Figure 4. **Standardised Cohen's differences for Y Balance test (YB) in anterior (Ant), posteromedial (Pm) and posterolateral (Pl) directions to right (R) and left (L) sides according to each group performances.** Error bars indicate uncertainty in true mean changes.

Discussion

The aim of this study was to investigate the effectiveness of a reaction time and eye-hand coordination training program to improve different physical performance abilities related with youth sports. Although RT and HEC are widely applied and studied in sport context, to the best of our knowledge no previous studies had evaluated its effects on the performance of youth athletes with a different sport background. The study outcomes provided by the majority of assessment tests, suggest that the experimental training stimulus was not meaningful to enhance reaction, agility and sprint performance. Nonetheless, the results showed an important beneficial effect on dynamic balance and postural stability, and in short-distance acceleration.

Despite all EG subjects displayed high significant improvements in balance, particularly in posteromedial and posterolateral directions, the CG also presented significant enhancements. Results similar to those, have been reported before (Aydin et al., 2002; Lephart et al., 1996), revealing that sport participation improves balance, as result of the large number of related stimulus incorporated in most of sport practice. In fact, this information supports the increasing importance given to a proper balance control and injury prevention in sport practice (Lai et al., 2017). Despite no relevant scientific evidences has been found that could relate RT or EHC with balance, the observed improvements in EG could be consequence of the uninterrupted centre of gravity changes required during our program training drills; since the subjects need to move all body, as fast as possible, between different places (i.e., the athlete often had the need to support the body in a single leg and quickly change the body position to perform the task). The improvement differences between EG to CG suggest the inclusion of specific RT and EHC training routines that required constant changes of direction in a regular training pattern, to benefit sport performance and injury prevention (Shaffer et al., 2013).

Sprint running was previously defined as a multidimensional skill (Markovic, Milanovic & Metikos, 2007), being the time taken to sprint from a stationary start over a relatively short distance commonly considered as a reflection of acceleration capability (Young et al., 2008). Moreover, reaction time, movement time and response time are considered as key contributors to an optimal sprint start. An excellent start and reduction of the duration of each of these components can contribute to a faster start time, and consequently a better sprint performance and a better standard of performance during a sprint. (Majumdar, & Robergs, 2011). Thus, the results shows that the inclusion of RT and EHC routines in athletes' training sessions can be an important strategy to develop their capacity to move quickly in a short space and increase speed in the first phase of a sprint displacement.

Surprisingly, both training groups showed a meaningful increase in upper body and limb velocity. Even being RT and EHC training characterized by fast upper body and limb movements and high coordination levels, the overall improvements obtained on Plate Tapping Test were similar for both groups. This condition is likely to be related to the issue of trainability and the specificity of the task. Indeed, literature (Forteza, 2004) showed that upper body RT is a tough ability to train and may depend on the genetic of each individual, limiting the probability of making significant improvements in a short period of time and few training sessions.

The current training program did not present the expected outcomes to the participants on agility and speed performance, despite some of our subjects being in a “sensitive” stage to develop both capacities (Balyi & Hamilton, 2004). The absence of tasks involving the running capacity in Batak Pro™ training routines (all the tasks are performed in the same area near the equipment’s interactive board), could be the reason for that, since both 30-m sprint and ‘5-0-5’ agility test, required that the athlete ran a considerable distance. In fact, it was previously reported that reaction time does not correlate with the sprint performance, more dependent of maximum speed, being inversely proportional to the length of the sprint distance (Mero et al., 1992). On other hand, concerning the Reactive Agility test, the results obtained, may be due to the fact, that this assessment test should involve highly specific training that recognizes the specific demands of the sport to be improved (Sheppard &Young, 2006).

Conclusions and Practical Implications

This study provides valuable information for sport coaches, displaying that reaction time and eye-hand coordination training has positive effects on acceleration capability and on static and dynamic balance skills of youth athletes with a different sport background. Thus due to its characteristics, *BATAK Pro*™ demonstrates to be a useful training instrument to improve different sport physical abilities in an alternative and didactic way, with training routines that are functional for several sports, according to the training goals and the athletes' characteristics. This may be specially relevant for athletes of different ages, in particular to those situated in the optimal trainability windows, whose activity involves fast reaction to different stimulus, dynamic balance and fast acceleration tasks. Furthermore, our findings also suggests that the inclusion of such a training routine may also contributing to a reduction of injury incidence. Despite that, further research is suggested to optimize the training prescription for the inclusion of this type of training, and future studies should isolate skills to be trained, to be sure that the training is effective to the physical enhancements required, in order to reinforce a positive relationship to sport performance.

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