RBCDH Revista Brasileira de CINEANTROPOMETRIA e Desempenho Humano

DOI: http://dx.doi.org/10.5007/1980-0037.2015v17n2p125

original article

Effects of technical training in functional asymmetry of lower limbs in young soccer players

Efeitos do treino técnico na assimetria funcional dos membros inferiores de jovens futebolistas

José Guilherme[1,2]
Júlio Garganta[1,2]
Amândio Graça[1,2]
André Seabra[1,3]

Abstract – The functional asymmetry of the lower limbs has been considered an important factor in the performance of soccer players. In this sense, the purpose of this study was to examine the effects of specific technical training for non-preferred foot on its utilization rate during the game; and to investigate if interruption of a technical training programme for the non-preferred foot influences its utilization rate during the game. Fifty young soccer players were randomly divided into two groups: G1 (n=26, 9.50±1.04 years) and G2 (n=24, 9.58±1.02 years). At the beginning of the first 4 months, each player's use of both feet during the game was assessed. The study lasted eight months divided into two periods of four months. In the first training period G1 was subjected to a technical training programme directed to the non-preferred foot, while G2 had no constraints on the use of both feet. At the end of the 4th month the two groups were newly assessed. During the second training period G1 and G2 reversed the training programmes. After the 8 months of training the evaluation of the utilization rate of both feet during small-side games was again performed. The main conclusions of the study were: (i) the technical training of the non-preferred foot allowed significant increases in its utilization rate during small-sided games; (ii) the interruption of such training partially reversed this effect. Thus, technical training for the non-preferred foot should be systematically performed in order to maintain the positive effects induced over functional asymmetry.

Key words: Motor Skills; Psychomotor Performance; Soccer; Task Performance and analysis; Test Taking Skills.

Resumo – *A assimetria funcional dos membros inferiores é considerada um fator relevante para o desempenho dos futebolistas. O presente estudo teve como propósitos: verificar se um programa de treinamento técnico para o pé não-preferido promovia o aumento do seu índice de utilização durante o jogo; e indagar se a interrupção do programa de treinamento técnico seria acompanhada pela inversão desse efeito. Cinquenta jovens futebolistas foram divididos aleatoriamente em dois grupos: G1 (n=26; 9,50±1,04 anos) e G2 (n=24; 9,58±1,02 anos). Antes do início do programa de treinamento avaliou-se em jogos reduzidos o índice de utilização de ambos os pés de cada jogador. O programa de treinamento teve a duração de 8 meses, divididos em dois períodos de 4 meses. Durante o primeiro período submeteu-se o G1 a um protocolo de treinamento do pé não preferido, enquanto que o G2 serviu de grupo controlo. Durante o segundo período de 4 meses o G1 interrompeu o treinamento técnico enquanto o G2 passou a realizar treinamento técnico. Terminados os 8 meses do programa de treinamento os dois grupos foram sujeitos a nova avaliação do índice de utilização dos membros inferiores. Concluiu-se que (i) o treinamento técnico direcionado para o pé não preferido permitiu aumentar significativamente o respetivo índice de utilização durante jogos reduzidos e que (ii) a interrupção do treinamento revertia de forma parcial este efeito. Deste modo, o treinamento técnico do pé não preferido de jovens futebolistas deverá ser sistemático de forma a que os efeitos positivos sobre a assimetria funcional possam ser mantidos.*

Palavras-chave: *Análise e desempenho de tarefas; Desempenho psicomotor; Destreza motora; Futebol; Habilidades para realização de testes.*

1 University of Porto. Faculty of Sport. Porto. Portugal.

2 University of Porto. Centre of Research, Education, Innovation and Intervention in Sport. Porto. Portugal.

3 Research Centre in Physical Activity, Health and Leisure. Porto. Portugal.

Received: 26 May 2014
Accepted: 14 January 2015

INTRODUCTION

There is unanimity in considering that the performance of a soccer player is multifactorial[1,2]. There are several studies highlighting the importance of the use of both preferred and non-preferred lower limbs, and its proficiency in game setting[3]. This issue leads to the analysis of the functional asymmetry of the soccer player's lower limbs and the strategies to promote its reduction.

Human beings use their limbs differently, showing preference for the use of one of the symmetrical parts of the body. This is known as functional asymmetry, which is seen as a dynamic process once it emerges from the interaction of genetic, neurological and sociocultural factors along with all the life experiences and persistent training in the case of sports[4]. Nevertheless, these asymmetries may be related to the preference or the proficiency. Thus, in order to determine the limbs preference or proficiency, it is important to set the task to be observed. One of the limbs may be chosen for a certain task, for example, passing the ball, whereas the other, the non-preferred limb for this task, will assume the role of preferred limb in keeping body stability[4,5].

The process adopted in order to increase the utilization rate of the non-preferred foot was the implementation of an exclusive technical training programme for this lower limb. In the soccer domain, systematic training which players are exposed to during their career influences the use of one or both limbs, as the player's decisions are influenced by the specific motor skills proficiency[6,7]. Thus, if a player has not mastered a skill, for example, if he is not able to pass the ball with the non-preferred foot, such option will not make part of his decision-making repertoire and, therefore, does not represent an eligible action. Consequently, the learning and development of specific motor skills of the non-preferred limb should happen at an early stage as an obligation so as to be soon recognized by the body as a new perceptual receiver, becoming an active part of new couplings of action perception[8] so that it is suitably used in match context.

Considering these assumptions, it seems relevant to check the influence of motor skills specific training in reducing functional asymmetry of the lower limbs of soccer players in game setting. In consequence, it becomes pertinent to verify if there is an increased asymmetry when stopping the practice. In this scoop, retention tests are often used to confirm the degree of learning in a particular task after an extended time period without being directly exercised. Several authors[9] highlight the importance of distinguishing the concepts of performance and learning. Performance is related to the immediate practical effects, induced by drilling or practice of a specific task, whereas learning relates to real effects in the subject promoted by practice, being, therefore, long-lasting effects. Thus, in order to assess the learning levels, retention tests are used. This procedure seems to be relevant because it may provide important information concerning the amount and durability of technical training for the non-preferred foot so that it becomes, increasingly, a possibility of use in game circumstances.

Several studies highlight the influence of motor skills training in the

reduction of asymmetries[10,11]. However, the protocols used were conducted outside the competitive context, making it unfeasible to confirm the increase of the use of the non-preferred foot in game situation. Taking these assumptions into account, it is relevant to study the influence of specific motor skills training in reducing soccer players' functional asymmetry of the lower limbs in game situation, as well as determine the consequences that its interruption causes.

Thus, the main purposes of this study were: (i) to examine the effects of specific technical training for non-preferred foot on its utilization rate during the game; and (ii) to investigate if the interruption of a technical training programme for the non-preferred foot influences its utilization rate during the game.

METHODOLOGICAL PROCEDURES

Participants

Fifty-three male Under-12 soccer players (9.54±1.03 years; $IC_{95\%}$: 9.25 to 9.83 years) from a Portuguese elite soccer team were studied and of these 50 completed the programme. Three players were excluded due to injuries or dropouts. These fifty players were randomly assigned in two groups: group 1 (G1; n=26; mean age 9.50±1.04 years) and group 2 (G2; n=24; mean age 9.58±1.02 years). Sample size calculations were performed for repeated measures ANOVA using the G*Power software 3.1.9.2. Hypothesizing an effect size (Cohen's d) of 1.0 for a required power of 95% at $p<0.05$, a sample size of at least twenty children was required. Therefore, a larger sample size should provide adequate power for detecting both differences. To be included in this study, participants had to be between 8 to 11 years of age and had at least 1 year of experience. All players were interviewed in order to provide information concerning the number of years of soccer practice and hours of regular training per week. Players had an average of 2 years of soccer experience with a range from 1 to 4 years (G1, 1.96±1.04 years; G2, 2.04±1.04 years) and participated in three training sessions per week (90min) and one official match per week (60min). A higher proportion of players used the right foot as the preferred foot (84%) compared with the left (16%).

After explaining the study procedures and protocol to the team coaches, soccer players and their parents consent was obtained. Study participation was voluntary; players were free to withdraw at any time. The study was approved by the ethical committee of the Faculty of Sport of the University of Porto and by clubs authorities.

Experimental design

The programme extended for 8 months. A baseline assessment on the functional asymmetry of the lower limbs was applied through a specific test, the "System of assessment of functional asymmetry of the lower limbs in Football" (SAFALL-FOOT)[12]. After assessment and for a period of 4 months, 3 times a week in the first twenty minutes of the training sessions,

G1 was submitted to a programme of technical training, which consisted of exercising specific motor skills directed exclusively to the non-preferred foot, while G2 was subjected to a programme with no restrictions or any specific concern on the use of the lower limbs. When the twenty minutes were over, both groups continued the training sessions performing the same exercises without any restriction or constraints on the use of the lower limbs. After the 4-month period, the two groups were reassessed through SAFALL-FOOT. Between fourth and eighth month period, the procedures of both groups were reversed: G2 adopted the training programme used previously with G1, whereas G1 adopted the programme used by G2. After eight months, both groups were newly assessed by SAFALL-FOOT, being G1 submitted to a retention test once it was not subject to a specific training programme in the final four months.

The retention tests are used to verify the degree of learning that a particular task presents after an extended period of time without being directly exercised[9]. Accordingly, retention tests distinguish effects of performance and effects of learning. The former relate to the immediate practical effects caused by the drilling or practice of a specific task. The second are associated to mediate effects, which practice has promoted on the subject, being these long lasting effects.

The training protocol consisted of the drilling of technical exercises, but not in game context so as to be able to control the use of the non-preferred foot. The exercises included the different specific motor skills of soccer (receiving, passing, driving, dribbling, shooting, disarm/interception), in isolation and in interaction. During the protocol, in all sessions, the different skills were constantly practised.

Measurement of functional asymmetry

In order to measure foot preference and functional asymmetry index, SAFALL-FOOT[12] was used. SAFALL-FOOT consists of 6 categories and 32 subcategories, allowing the analysis of the quantity and effectiveness of all technical actions performed with the ball, using the lower limbs during a 20 min five-a-side football game, which was filmed for further observation (Table 1). This analysis yields a utilization index of the preferred and non-preferred foot in the game, and, consequently, provides the respective functional asymmetry index.

The equations used to calculate the utilization ratio of both members are:

- "Preferred foot" =

Score of the positive subcategories of the "preferred foot" + score of the negative subcategories of the "preferred foot"/Σ of the actions performed (subcategories: "preferred foot" and "non-preferred foot")

- "Non-preferred foot" =

Score of the positive subcategories of the "non-preferred foot" + score of the negative subcategories of the "non-preferred foot"/Σ of the actions performed (subcategories: "preferred foot" and "non-preferred foot")

Table 1. Presentation and score of the categories and subcategories "SAFALL-FOOT".

Categories	Subcategories	Score
Interception/Disarm	Interception/Disarm-right foot-positive	10,00
	Interception/Disarm-right foot-negative	2,50
	Interception/Disarm-left foot-positive	10,00
	Interception/Disarm-left foot-negative	2,50
Reception	Reception-right foot-positive	10,00
	Reception-right foot-negative	2,50
	Reception-left foot-positive	10,00
	Reception-left foot-negative	2,50
Passing	Passing-right foot-positive	10,00
	Passing-right foot–negative	2,50
	Passing-left foot-positive	10,00
	Passing-left foot-negative	2,50
Driving/Protection	Driving/Protection-right foot-positive	10,00
	Driving/Protection-right foot-negative	2,50
	Driving/Protection-left foot-positive	10,00
	Driving/Protection-left foot-negative	2,50
	Driving/Protection-dominance of right foot-positive	
	Right-foot	10,00
	Left-foot	5,00
	Driving/Protection-dominance of right foot-negative	
	Right-foot	2,50
	Left-foot	1,25
	Driving/Protection-dominance of left foot-positive	
	Right-foot	5,00
	Left-foot	10,00
	Driving/Protection-dominance of left foot-negative	
	Right-foot	1,25
	Left-foot	2,50
Feint/Dribble	Feint/Dribble-right foot-positive	10,00
	Feint/Dribble-right foot-negative	2,50
	Feint/Dribble-left foot-positive	10,00
	Feint/Dribble-left foot-negative	2,50
	Feint/Dribble-dominance of right foot-positive	
	Right-foot	10,00
	Left-foot	5,00
	Feint/Dribble-dominance of right foot-negative	
	Right-foot	2,50
	Left-foot	1,25
	Feint/Dribble-dominance of left foot-positive	
	Right-foot	5,00
	Left-foot	10,00
	Feint/Dribble-dominance of left foot- negative	
	Right-foot	1,25
	Left-foot	2,50
Shooting	Shooting-right foot-positive	10,00
	Shooting-right foot-negative	2,50
	Shooting-left foot-positive	10,00
	Shooting-right foot-negative	2,50

The final score ranges from 0 to 10. The use of the preferred foot and non-preferred foot is lower the more the values approach zero and higher the more they approach ten. The difference between the values of the right and the left feet corresponds to the functional asymmetry revealed by the performer. For more detailed analysis, consult SAFALL-FOOT guidelines[12].

Statistical procedures

Descriptive statistics (means and standard deviations) were calculated for the two groups at baseline, 4 and 8 months. None of the characteristics analysed showed significant deviations from a normal distribution (Shapiro-Wilk test). Baseline differences in mean characteristics between G1 and G2 were tested with unpaired sample t-tests. Intervention effects were examined by with a two-factorial repeated measures analysis of variance (factor 1: time, factor 2: groups) followed by Bonferroni's post hoc analyses. For each characteristic, percentage of changes (%Δ) between baseline 4 and 8 months were also calculated; the difference was then divided by baseline value. Significance level in all analyses was set at 0.05. Statistical analyses were conducted using SPSS version 21.0.

RESULTS

Regarding the preferred foot a significant main effect for time ($F=25.88$, $p<0.001$) and a significant group by time interaction ($F=23.34$, $p<0.001$) were found (Table 2). This suggests that the time effects in the preferred foot differed between G1 and G2 (Figure 1). Mean values of the preferred feet in G1 decreased significantly between the baseline and 4 months (%Δ=-9.53, $p<0.001$), while in G2 players mean values remained rather constant during this period (%Δ=+0.73, $p=0.99$). Between 4 and 8 months, preferred foot significantly improved in G1 with the technical training (%Δ=+4.51, $p=0.005$), whereas in G2 decreased significantly (%Δ=-6.28, $p<0.001$). In addition, after 8 months, the preferred foot decreased significantly in both groups (G1: %Δ=-6.72, $p<0.001$; G2: %Δ=-6.21, $p<0.001$) compared to baseline values.

A significant main effect for time ($F=95.52$, $p<0.001$) and a significant group by time interaction ($F=63.73$, $p<0.001$) were also observed for the non-preferred foot. This significant interaction suggests that the time effects in the non-preferred foot differed between G1 and G2 (Figure 1). Between the baseline and 4 months, non-preferred foot significantly improved in G1 with the technical training (%Δ=+115.86, $p<0.001$), whereas in G2 it remained rather constant across this period (%Δ=-5.02, $p>0.05$). Between 4 and 8 months, G1 decreased significantly their values (%Δ=-15.232, $p<0.001$), whereas in G2 a significant increase was observed (%Δ=+94.51, $p<0.001$). In addition, after 8 months, the non-preferred foot increased significantly in both groups (G1: %Δ=+32.27, $p<0.001$; G2: %Δ=+44.53, $p<0.001$) compared to baseline values (Figure 2).

Table 2. Mean values (standard deviations), F-test and P value for repeated measures analysis of variance (ANOVA) for the preferred foot (PF) and non-preferred foot (NPF).

		Groups		ANOVA		
	Time	G1	G2	Time	Groups	Time*Groups
Preferred foot	Baseline	7.77 (0.58)	7.62 (0.56)	25.88 (<0.001)	1.15 (0.289)	23.34 (<0.001)
	4 months	7.00 (0.50)	7.66 (0.48)			
	8 months	7.29 (0.45)	7.17 (0.40)			
Non-preferred foot	Baseline	0.95 (0.42)	0.98 (0.34)	95.52 (<0.001)	2.26 (0.140)	63.73 (<0.001)
	4 months	1.73 (0.38)	1.01 (0.34)			
	8 months	1.45 (0.42)	1.75 (0.22)			

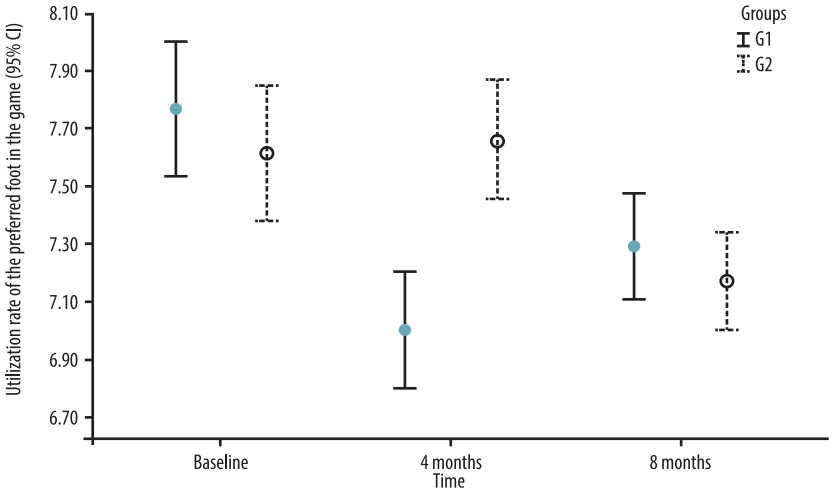

Figure 1. Mean values and respective 95% confidence intervals for the utilization rate of the preferred foot in the different groups at baseline, and after 4 and 8 months.

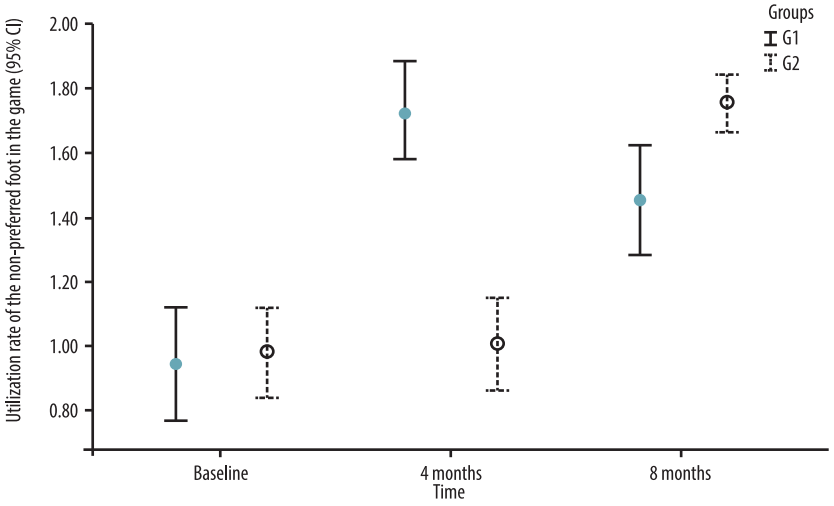

Figure 2. Mean values and respective 95% confidence intervals for the utilization rate of the non-preferred foot in the different groups at baseline, and after 4 and 8 months.

DISCUSSION

The present study intended to examine the effects of a specific technical training programme on the utilization rate of the non-preferred foot during the match. The main results showed that a specific technical training programme for the non-preferred foot has effective impact on its increased use during the game, since both groups, G1 and G2, developed their utilization index significantly after carrying out the technical training programme. Another finding was the rate reversibility concerning the use of the non-preferred foot in the game context after the break of the specific technical training programme, once G1 reduced considerably the use of the non-preferred foot after the four-month suspension of technical training. However, despite this decrease from the fourth to the eighth month, it appears that the values found for G1 between the

baseline and the eighth month show a significant increase in the use of the non-preferred foot.

These results enable us to reflect on different issues. The first relates to the recognition that the technical training programme for the non-preferred foot, to which the groups were submitted, shows a positive learning transfer to the game setting. The concept of transfer is defined as the effect which the practice of a skill expresses in the performance of that same skill in different contexts or in the acquisition and learning of other skills[9]. The results show that the technical training of the non-preferred foot outside the game context has positive transfer in competition.

This statement raises an important pedagogic question: what is the importance of technical practice in the development of specific motor skills in soccer training? Based on the results, it is important both by the increase of the utilization rate of the non-preferred foot in G1 and G2, in the first and second periods respectively, as by the decrease in G2, in the second period. These data seem to be relevant, also from a pedagogical point of view. In fact, the expression of a specific motor skill elapses from a complex process of adaptation involving perceptual, cognitive, decision and action mechanisms[1]. This justifies that skill training includes situations of high variability, adapted and differentiated complexity of ecological purpose and versatility identical to those which are requested by conditioned or formal game situations[9,13]. If so, the training of technical skills will have an ecological approach rather than associated with disconnected tasks. Moreover, the characteristics of such training lead the technical training to be proactive. Finally, with a specific technical motor skills programme, it seems possible to solve the problem concerning the reduced amount of practice of some specific motor skills when in game situation, thereby promoting individual performance.

A second relevant issue of this study was to investigate the dynamic feature which characterizes laterality[4]. Several authors[10,11] found that the functional asymmetry of the lower limbs tends to reduce when there is a systematic increase in training of the non-preferred limb, as can be confirmed in our study. However, it was also noticed that when that systematic training is interrupted, the functional asymmetry increases again.

Possible explanations for understanding this dynamic of asymmetry can be found at the intersection of information arising from the effects of performance and learning[9], skill acquisition[13-14] and also from the perspective of ecological approach by study[8]. As previously mentioned, the learning effects are those that persist after an extended period of time without the task to be learned being directly exercised[9]. Thus, the values found for G1 at 4 months and G2 at 8 months are the values of performance, while the values of G1 at eight months represent the real consequences of learning.

These ideas provide the understanding of the dynamic characteristics that asymmetry gathers and the reasons why G1, after the second four-

month period, showed reversibility of the use of the non-preferred foot. On the one hand, there is the need to distinguish the effects of learning and the effects of performance. On the other hand, it is important to recognize that the acquisition of motor skills may not have acquired yet an autonomous stage, because the amount of drilling was not large enough compared to the years of practice the other limb was subjected to, and perceptive mechanisms, by not being systematically stimulated, the body fails to recognize them as mechanisms of action perception since it has other perceptive receivers to perform identical actions, which along the specific experiences were much more stimulated. This data seems relevant to emphasize that the training of the non-preferred limbs should not be simply circumstantial, but systematic. Thus, a systematic and extended practice of a non-preferred limb gives a performance profile identical to the preferred limb[15,16]. In this sense, the training process should be organised from the initial stages of learning, with the aim of providing both limbs to be equally requested.

There is a common belief that persistent training with the non-preferred foot causes a decrease in the variability, versatility, creativity and, therefore, quality of the preferred foot. However, the expertise and functional symmetry of both lower limbs provides the soccer player with a greater multiplicity of actions, allowing greater creativity and proficiency. This idea is confirmed in studies emphasizing that the reduced level of performance of the non-preferred limb affects the ability of the preferred limb[10,11,17].

The design of this study faced some constraints as to its feasibility, particularly because of the need to interfere as little as possible with the dynamic preparation of the analysed teams. Thus, the amount of exclusive training for the non-preferred foot was greatly reduced compared to the training without any restrictions, which may limit the results obtained concerning the reduction of the asymmetry. However, this apparent limitation became an advantage, since the design of the study found the ecological requirements due to the reduced contextual interference. Also because it has demonstrated that a small percentage of time of exclusive practice of the non-preferred foot (20 minutes in each 90 minutes of the training session, 3 times a week, for a period of four months) allowed a significant increase in the use of the non-preferred foot during the game. This is consistent with the idea of study[18] that suggests that the increase in the performance of technical skills may be achieved through little structured practice. Nevertheless, further practice leads to a proficient development and therefore several authors suggest that if higher performance is intended, practice should be extended[19]. There is one limitation in this study that should be considered when interpreting the results. Although the results are relevant, the conclusions that can be drawn should be interpreted specifically in relation to the present sample. Findings may not generalize to other age categories and competition levels and may be specific to the elite soccer under 12 teams.

CONCLUSIONS

In summary, a specific training protocol for the non-preferred foot has positive implications in the utilization rate of the respective limb during the game when compared to a protocol without any constraint on the use of the lower limbs. It also confirms the dynamic characteristic of laterality. When there are systematic stimuli directed to the non-preferred foot, the effects are positive. However, when these stimuli are interrupted reversibility happens, as proved by retention test. Finally, in order to get positive and lasting implications in the rate of utilization during the game, training for the non-preferred foot should be systematic and not circumstantial.

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Corresponding author

José Guilherme
Centre of Research, Training, Innovation and Intervention in Sport (CIFI2D)
Faculty of Sport, University of Porto, Portugal
Rua Dr. Plácido Costa, 100
4200.450 Porto, Portugal
E-mail: goliveira@fade.up.pt