DOI: 10.4025/jphyseduc.v27i1.2757

Original Article

PACING STRATEGY IN SPEED SKATING: INFLUENCE OF THE GENDER AND RACE'S PERFORMANCE LEVEL IN 1500-M DISTANCE

ESTRATÉGIA DE PROVA EM PATINAÇÃO DE VELOCIDADE NO GELO: INFLUÊNCIA DO GÊNERO E NÍVEL DE DESEMPENHO DAS PROVAS DE 1.500

Carlos Rafaell Correia-Oliveira[1], Mayara Vieira Damasceno[1], Alan de Albuquerque Melo[2], Rômulo Bertuzzi[1] e Maria Augusta Peduti Dal'Molin Kiss[1]

[1]Universidade de São Paulo, São Paulo-SP, Brasil.
[2]Universidade Federal de Alagoas, Maceió-AL, Brasil.

RESUMO

Nosso objetivo foi analisar a estratégia de prova adotada em patinação de velocidade de média distância e a influência do gênero e o nível de desempenho das provas sobre a estratégia. Foram incluídas provas masculinas e femininas de cinco etapas da Copa do Mundo realizada na temporada 2009/2010. Em ambos os gêneros, as provas foram classificadas como alto (AD) e baixo (BD). A estratégia adotada foi similar entre os gêneros, com os atletas masculinos sendo mais rápidos durante toda a prova ($P < 0,05$). As provas de AD foram mais agressivas em todas as parciais comparadas às provas de BD ($P < 0,05$), independente do gênero. Embora o desempenho seja diferente entre os gêneros, a estratégia adotada foi similar entre eles nas provas mais rápidas e mais lentas, sugerindo que a técnica de movimento em atletas de elite parece ser um fator determinante na escolha da estratégia adotada.

Palavras-chave: Desempenho atlético. Técnicas de exercício e de movimento. Patinação.

ABSTRACT

Our aim was to analyze the pacing strategy adopted during middle-distance speed skating and to verify the influence of gender and race's performance level on pacing adopted. The races of male and female athletes during five stages of a World Cup, season 2009/2010, were included in the study. In both genders, the races were classified as high (HP) and low (LP) performance. The pacing adopted was similar between genders, with male athletes being faster throughout the race ($P < 0.05$). In both genders, the HP races were more aggressive in all intervals compared to LP races ($P < 0.05$), regardless of gender. Although performance is different between genders, the pacing adopted was similar between them in faster and slower races, suggesting that the technical in elite athletes seems to be a determinant factor in choice of adopted pacing strategy.

Keywords: Athletic performance. Exercise movement techniques. Skating.

Introduction

The term "pacing strategy" may be named as the manner by which athletes distribute energy expenditure and consequently velocity during exercise in an attempt to improve performance[1-3]. In order to perform a trial as fast as possible and avoid exhaustion occurring before completing the trial, athletes adopt a pacing strategy[1,4,5]. In particular, it is well documented that in short and medium-distance events, athletes adopt a fast start strategy, with a later decline in speed at the end of the race[1,6-8].

In fact, it has been demonstrated that in sports with cyclic feature, such as cycling, running, rowing and swimming[6,9-11] is common athletes adopt some kind of pacing strategy, as an optimal distribution of speed/power output during such events is likely to have a direct influence on performance[2]. In addition to the studies aforementioned, another sport in which the use of different strategies is observed is speed skating, involving speed (shorter races) and resistance (long-duration races)[7,12]. According to ISU (International Skating Union), international speed skating competitions may include short (100, 500, 1000 and 1500 m) and

long (3000, 5000 and 10000 m) distances. The 3000-m race is exclusively for Ladies, while the 10000-m race is performed only by Men.

Specifically, the 1500-m race is performed by athletes of both genders and the duration is approximately two minutes. However, the importance of the adopted strategy on performance during short-duration speed skating trials has received limited attention to date[7,13,14]. In 2010, analyzing data from one stage of the 2007/2008 World Cup season, Muehlbauer, Schindler, and Panzer[7] reported the male and female athletes adopted a similar strategy characterized by a fast acceleration in the first split times of the 1500-m race followed by a gradual slowdown up to the end of the race. Subsequently, a significant reduction in performance (~ 2 s) was observed when an 'optimal' strategy model was applied in a 1500-m speed skating test[14]. The authors suggested the effort applied to increase the intensity at the beginning of the test when the strategy was imposed seems to result in changes in motion technique that are not favorable in speed skating, overlapping the benefit of a faster start. In this case, it would be interesting to analyze elite athletes during different stages of the same competitive season (e.g. World Cup Speed Skating), in an attempt to verify how these athletes distribute speed throughout these events, as the strategy profile for a 1500-m speed skating race is still not well established. Furthermore, these results would have a relevant practical implication as the pacing strategy adopted by these athletes would be analyzed in a real competition environment.

Therefore, the main aim of the present study was to describe and analyze the pacing strategy profile adopted by the athletes during different stages of the same competitive speed skating season in middle-distance races (1500 m). In addition, as factors such as gender and physiological condition of each athlete may influence the choice of the best strategy, we have also verified whether this sport and the level at which each race is performed (faster versus slower races) would influence the strategy adopted by the athletes.

Methods

Sample

Initially, it was conducted a survey of all the races carried out during the 2009/2010 season of the world cup speed skating in the 1500-m distance. During this season five stages were carried out in the period between November 6 and December 13, 2009 and two stages between March 6 and 14, 2010. Due to difference in time between the last race held in 2009 and the first race held in 2010 (approximately three months), it was only analyzed the races carried out at 2009. Then, it was carried out a survey of all competitors of the 1500-m races, men and women, competing in the stages held between November and December 2009. As some athletes participated in more than one stage during this period (ranging from one to five stages), the total number of races took into account the analysis of different races performed by the same athlete (e.g. if a given athlete participated in three Stages, this athlete had three races analyzed).

If for any reason the race performed by an athlete did not have all of his/her velocity section disclosed during a given stage, that race was excluded as it was not possible to analyze its strategy. Thus, a total of 161 races performed by 74 male athletes and 148 races performed by 64 female athletes, who met all the criteria, were included in the study. All data was obtained through the official speed skating website, which has public access (www.isu.org). This site represents the official database of this modality used worldwide. In addition, this tool has been used in previous studies[12,15].

Data analysis

In each race, all the section velocities were recorded and the races performed by the athletes were ranked according to their performance time. The performance time and the split time were obligatorily recorded by an automatic timing system with the presence of a photofinish system, according to the ISU requirements for the 2009/2010 season. The speed in each section was divided as follows: 0-300 m (P1), 300-700 m (P2), 700-1100 m (P3) and 1100-1500 m (P4). These races were divided into terziles, excluding the races in terzile 2. From this division, the faster (terzile 1) and slower races (terzile 3) were classified as races of high (HP) and low (LP) performance, respectively[3]. For men, the performance time and the mean speed in the HP races were 104.2 ± 1.0 and 14.3 ± 0.1 m/s, respectively, whereas the LP races were performed in 112.7 ± 3.6 and 13.3 ± 0.3 m/s ($P<0.05$). Likewise, for ladies, the HP races were significantly faster (115.6 ± 0.1 and 12.9 ± 0.1 m/s) in relation to the LP races (123.9 ± 4.2 and 12.1 ± 0.2 m/s, $P<0.05$), thus confirming the efficacy of the classification presented for the races. It is worth noting that, for the gender comparisons, the division of the races into terzies was not performed, being therefore considered the total of races performed for men (n = 161) and ladies (n = 148). Taking into consideration the fact that some athletes, regardless of gender, did not perform all five races analyzed or that some race performed by such athletes was excluded of analysis, according to the criterion mentioned above, the reproducibility of the tests was not verified in the present study. However, it is believed that because they are world class athletes, a high reproducibility of races could be expected.

Statistical analysis

Data are presented as mean and standard deviation (mean ± SD). Performance time and mean speed were compared between genders and performance level of the races using a student's t-test for independent samples. The effects of the condition (gender or performance level of the race) and distance on speed were verified through a two-way ANOVA, followed by the Bonferroni post hoc test. All analyzes were performed using SPSS (16.0) software and the statistical significance was accepted at $P < 0.05$.

Results

Performance parameters

The male group was significantly faster than the female group (108.1 ± 4.3 vs. 119.7 ± 4.4 s, respectively; $P < 0.05$). Likewise, the mean speed of the race was significantly higher in the male group (13.8 ± 0.4 m/s) than in the female group (12.5 ± 0.4 m/s; $P < 0.05$).

Pacing strategy

In general, both genders adopted a similar pacing strategy, with a fast acceleration between the section P1 and P2, followed by a progressive and linear reduction in the speed of the following section (P3 and P4) ($P < 0.05$; figure 1). However, the male athletes were significantly faster than the female athletes in all the section of the race ($P < 0.05$; figure 1).

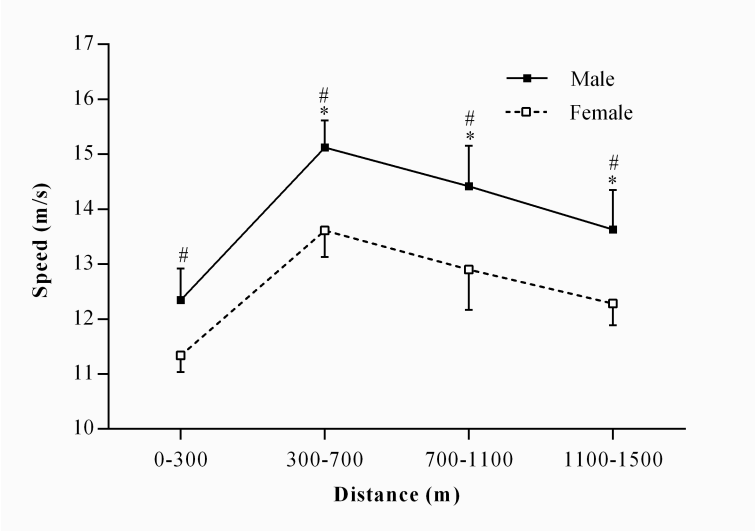

Figure 1. Mean and SD for speed during 1500-m speed skating race for men and ladies. # Significantly faster than female ($P < 0.05$). * Significantly different of the other speed sections in both groups ($P < 0.05$).
Source: Authors.

When separated by performance level, both male (HP and LP) races showed a similar pacing strategy pattern, with a gradual acceleration up to P2, followed by a decline in the P3 and P4 ($P < 0.05$, Figure 2). However, the HP races were significantly more aggressive in all the section when compared to the LP races ($P < 0.05$; figure 2).

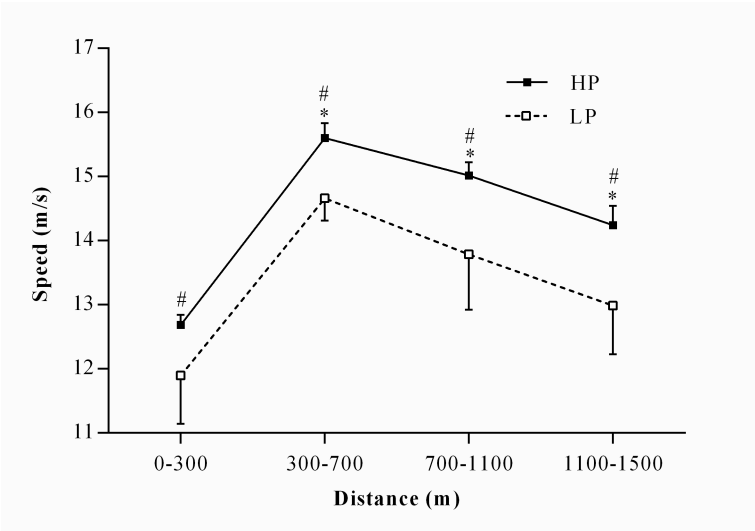

Figure 2. Mean and SD for speed during 1500-m speed skating race for male high and low performance races. HP: high performance race. LP: low performance race. # Significantly faster than LP ($P < 0.05$). * Significantly different of the other speed sections in both races ($P < 0.05$).
Source: Authors.

Similar to the male gender, the female HP and LP races also followed an acceleration pattern until near middle of the race, when then reduced the speed progressively until the end of the race ($P < 0.05$; figure 3). As in the male, all section of the HP races were faster than the LP races ($P < 0.05$; figure 3).

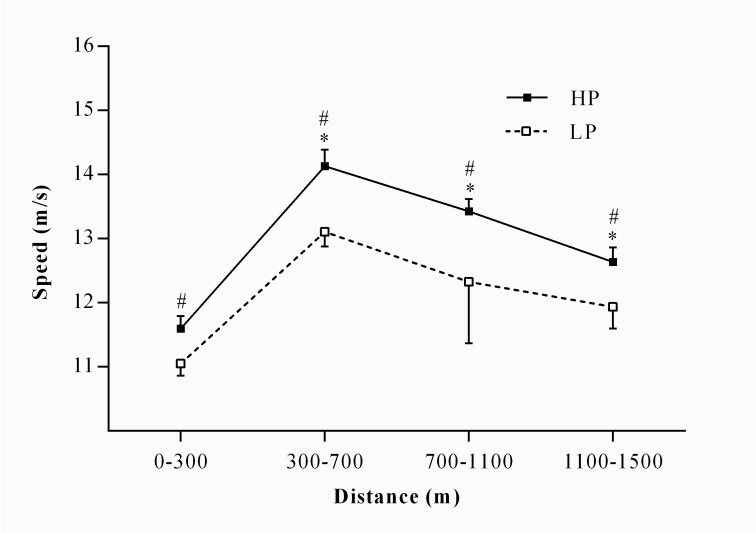

Figure 3. Mean and SD for speed during 1500-m speed skating race for female high and low performance races. HP: high performance race. LP: low performance race. # Significantly faster than LP ($P < 0.05$). * Significantly different of the other speed sections in both races ($P < 0.05$).

Source: Authors.

Discussion

The aim of the present study was to describe and compare the pacing strategy adopted by athletes in different stages of a world cup speed skating season. We also verified whether the gender and performance level at which the races were carried out would have any influence on the pacing strategy. The main findings of the present investigation were that: 1) the speed distribution profile during the race was similar among the competitors, characterized by an acceleration in the first part of the race, followed by a decrease in the speed in the following section until the end of the race, 2) male athletes were faster than female athletes throughout the race and 3) regardless of gender, the adopted strategy in the HP races were always more aggressive than in the LP races for all sections. From these findings, it may be suggested that the strategy profile adopted in middle-distance speed skating races is similar in elite athletes, regardless of the gender and performance level in which the race is performed. However, male athletes and HP races (in both genders) are more aggressive throughout the race.

In the present study, regardless of gender and performance level, the races performed by the athletes revealed a similar strategy, with a progressive acceleration up to P2 and a linear decline in the following section (P3 and P4). This similar profile of pacing strategy adopted may be due the high training level of sample analyzed (even when the races were ranked by terziles) and the previous experience of the athletes in this type of competition. In fact, the importance of the athlete's experience in choosing the best strategy for certain types of events is well established[16-18]. It is believed that prior experience is acquired by athletes over successive tests of the same distance[16]. Mauger, Jones and Williams[16] have observed that

when two groups of cyclists performed successive 4-km races (in which one of the groups did not receive feedback on the distance completed), the magnitude of time difference between groups decreased through the trials. It is suggested that the pacing strategy is regulated by the central nervous system, generating a conscious perception of effort which, based on the interpretation of afferent signals (e.g. exercise muscles) and the external environment, is adjusted continuously through prior experience acquired over repeated races[16,17].

This similar speed pattern adopted throughout the race may also be due to knowledge of the race's end point[19-22]. Although using a different type of exercise, but purposing to determine whether deception and endpoint knowledge would interfere on the pacing strategy during maximal tests with durations of 30-36 s, Ansley et al.[19] submitted 8 volunteers to six Wingate tests. The volunteers were informed that would perform four 30-s tests, one 33-s test and one 36-s test. However, the tests were manipulated and participants performed two trials for each duration: 30, 33 and 36 s. In all tests, regardless of time and manipulation, the volunteers adopted a fast acceleration at the beginning, followed by a progressive reduction in intensity, corresponding to a similar strategy to revealed in the present study. The power was similar between all tests performed up to 30 s, but in the 36-s test, in which time was manipulated (volunteers thought to be performing only 30 s) the power was significantly lower compared to the true 36-s test. The authors suggested due the similarity between strategies, regardless of duration, strategies are centrally regulated. Furthermore, the reduction in power in last 6 s of the 36-s test reinforces the assumption of a end point previously established based on anticipated exercise duration.

Our results are similar to the findings of Muehlbauer et al.[7] that also demonstrated the athletes start the race in an accelerated manner with a later decrease in speed during the end of the race after analyzing the speed distribution during a 1500-m speed skating test. However, Muehlbauer et al.[7] analyzed data from only one of the nine stages in the 2007/2008 world cup speed skating season (Calgary, Canada), which makes it hard to describe the pacing strategy profile adopted by the athletes. Therefore, the present study is the first to present, in fact, the pacing strategy profile adopted by high level athletes, through of successive stages of a competitive speed skating season 1500-m distance.

When the races performed by the athletes were compared in relation to the gender, although the speed distribution profile has been similar, time to complete the race and the speed of the male athletes (108.1 ± 4.3 s and 13, 8 ± 0.4 m/s, respectively) showed a higher performance for this group in relation to female athletes (119.7 ± 4.4 s and 12.5 ± 0.4 m/s, respectively). Biomechanically, women have a greater pre-extension knee angle, which may be a disadvantage, represented by a greater loss of speed due to the air friction in this type of event[12]. In addition, men have a greater muscle mass, absolute muscle strength and power output when compared to women[23], such factors considered important for performance in modalities such as speed skating[24]. Furthermore, analyzing world rankings from 1980 to 1996 in middle-duration (1500 m) races, Sparling, O'Donnell, and Snow[25] showed a 10-13% difference in performance between men and women, supporting the findings in the present study. In fact, the male group was approximately 10% better than the female group, reinforcing the idea that gender is a potential factor influencing performance.

Similar to comparison between genders, when the races classified as HP and LP were compared, the pacing strategy adopted in both races (faster and slower) was the same. As mentioned previously, the experience accquired by athletes over the time and after numerous repetitions of the same race, as well as knowledge of the end point of the race can aid in the best strategy to be adopted to achieve the desired aim. In turn, a factor able to influence the performance of faster (HP) or slower (LP) races is the motion technique. Although widely familiarized with this type of race, any change in motion technique may lead to different

performance races[24]. In a study conducted by Hettinga et al.[14] showed that when a fast-start strategy was imposed on the skaters, their performance was significantly impaired in relation to the condition in which the strategy was freely adopted by the athletes. Hettinga et al.[14] highlighted the importance of adequate maintenance of the body position and knee joint angle during the race. According the authors, the effort to increase the intensity at the beginning, in the condition in which the strategy was imposed seems to result in technical changes unfavorable for speed skating, which could lead to the development of premature fatigue and consequent loss of technical capacity, the latter by increasing the frontal area and the knee joint angle, which, in turn, would lead to increased air resistance.

It is worth noting that the results of the present study were restricted to those provided by the ISU website, which discloses all the results of official competitions of this sport, which may be a limitation in obtaining data. However, these results refer to real competition situations, demonstrating more precise responses regarding the athletes' behavior during the race in terms of the speed imposed and the adopted strategy pattern, as the athletes are not influenced by the laboratory environment, which makes the present study to have a high degree of external validity, representing the exact situation of those occurring in a speed skating race of this nature.

Conclusion

The results of the present study reveal that in 1500-m speed skating competitions, the pacing strategy is characterized by a gradual acceleration up to half the race, followed by a decline in speed that extends to the end of the event. In addition, the pacing strategy adopted by both genders and race performance levels was similar, reinforcing the notion that, in high-level athletes such as those in the present study, the motion technique seems to be a strong determining factor in choice of the pacing strategy.

References

1. Abbiss CR, Laursen PB. Describing and understanding pacing strategies during athletic competition. Sports Med 2010;38(3):239-252.
2. Jones AM, Wilkerson DP, Vanhatalo A, Burnley M. Influence of pacing strategy on O2 uptake and exercise tolerance. Scand J Med Sci Sports 2008;18(5):615-626.
3. Lima-Silva AE, Bertuzzi RC, Pires FO, Barros RV, Gagliardi JF, Hammond J, et al. Effect of performance level on pacing strategy during a 10-km running race. Eur J Appl Physiol 2010;108(5):1045-1053.
4. Foster C, Schrager M, Snyder AC, Thompson NN. Pacing strategy and athletic performance. Sports Med 1994;17(2):77-85.
5. St Clair Gibson A, Schabort EJ, Noakes TD. Reduced neuromuscular activity and force generation during prolonged cycling. Am J Physiol Regul Integr Comp Physiol 2001;281(1):R187-196.
6. Hanon C, Leveque JM, Thomas C, Vivier L. Pacing strategy and VO2 kinetics during a 1500-m race. Int J Sports Med 2008;29(3):206-211.
7. Muehlbauer T, Schindler C, Panzer S. Pacing and performance in competitive middle-distance speed skating. Res Q Exerc Sport 2010;81(1):1-6.

8. Thomas C, Hanon C, Perrey S, Le Chevalier JM, Couturier A, Vandewalle H. Oxygen uptake response to an 800-m running race. Int J Sports Med 2005;26(4):268-273.

9. Corbett J. An analysis of the pacing strategies adopted by elite athletes during track cycling. Int J Sports Physiol Perform 2009;4(2):195-205.

10. Garland SW. An analysis of the pacing strategy adopted by elite competitors in 2000 m rowing. Br J Sports Med 2005;39(1):39-42.

11. Thompson KG, MacLaren DP, Lees A, Atkinson G. The effects of changing pace on metabolism and stroke characteristics during high-speed breaststroke swimming. J Sports Sci 2004;22(2):149-157.

12. Muehlbauer T, Panzer S, Schindler C. Pacing pattern and speed skating performance in competitive long-distance events. J Strength Cond Res 2010;24(1):114-119.

13. Hesford CM, Laing S, Cardinale M, Cooper CE. Effect of race distance on muscle oxygenation in short-track speed skating. Med Sci Sports Exerc 2013;45(1):83-92.

14. Hettinga FJ, De Koning JJ, Schmidt LJ, Wind NA, Macintosh BR, Foster C. Optimal pacing strategy: from theoretical modelling to reality in 1500-m speed skating. Br J Sports Med 2011;45(1):30-35.

15. Muehlbauer T, Melges T. Pacing patterns in competitive rowing adopted in different race categories. J Strength Cond Res 2011;25(5):1293-1298.

16. Mauger AR, Jones AM, Williams CA. Influence of feedback and prior experience on pacing during a 4-km cycle time trial. Med Sci Sports Exerc 2009;41(2):451-458.

17. Micklewright D, Papadopoulou E, Swart J, Noakes T. Previous experience influences pacing during 20 km time trial cycling. Br J Sports Med 2010;44(13):952-960.

18. St Clair Gibson A, Lambert EV, Rauch LH, Tucker R, Baden DA, Foster C, et al. The role of information processing between the brain and peripheral physiological systems in pacing and perception of effort. Sports Med 2006;36(8):705-722.

19. Ansley L, Robson PJ, St Clair Gibson A, Noakes TD. Anticipatory pacing strategies during supramaximal exercise lasting longer than 30 s. Med Sci Sports Exerc 2004;36(2):309-314.

20. Billaut F, Bishop DJ, Schaerz S, Noakes TD. Influence of knowledge of sprint number on pacing during repeated-sprint exercise. Med Sci Sports Exerc 2011;43(4):665-672.

21. Paterson S, Marino FE. Effect of deception of distance on prolonged cycling performance. Percept Mot Skills 2004;98(3 Pt 1):1017-1026.

22. Swart J, Lamberts RP, Lambert MI, Lambert EV, Woolrich RW, Johnston S, et al. Exercising with reserve: exercise regulation by perceived exertion in relation to duration of exercise and knowledge of endpoint. Br J Sports Med 2009;43(10):775-781.

23. Perez-Gomez J, Rodriguez GV, Ara I, Olmedillas H, Chavarren J, González-Henriquez JJ, et al. Role of muscle mass on sprint performance: gender differences? Eur J Appl Physiol 2008;102(6):685-694.

24. van Ingen Schenau GJ, de Groot G, Hollander AP. Some technical, physiological and anthropometrical aspects of speed skating. Eur J Appl Physiol Occup Physiol 1983;50(3):343-354.

25. Sparling PB, O'Donnell EM, Snow TK. The gender difference in distance running performance has plateaued: an analysis of world rankings from 1980 to 1996. Med Sci Sports Exerc 1998;30(12):1725-1729.

Acknowledgments: The authors are grateful Professor Adriano Eduardo Lima-Silva, Sports Science Research Group, Federal University of Pernambuco, Pernambuco, Brazil, for his intellectual contribution to the study design and critical comments.

Received on Sep, 19, 2015.
Reviewed on Fev, 29, 2016.
Accepted on Jul, 27, 2016.

Author address: Carlos Rafaell Correia-Oliveira. School of Physical Education and Sport – University of Sao Paulo (USP), Avenida Professor Mello de Morais, 65, Cidade Universitária – São Paulo – SP – Brasil. Postcode: 05508-030. Email: correia-oliveiracr@usp.br