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Original article

Relación entre la capacidad aeróbica y de salto como estrategia optimizadora del rendimiento atlético en corredores aficionados

Relationship between aerobic capacity and jumping as strategy for optimizing athletic performance in amateur runners

Relação entre a capacidade aeróbica e de saltos como estratégia para otimizar o desempenho atlético dos corredores amadores

Héctor Fuentes-Barria^{1*}  <http://orcid.org/0000-0003-0774-0848>

Diego Valenzuela-Pérez¹  <https://orcid.org/0000-0002-9884-1187>

Rodrigo Fuentes- Kloss¹  <https://orcid.org/0000-0003-1698-7519>

¹Universidad Santo Tomas, Chile.

*Corresponding author: h3ct0r.fuentes@gmail.com

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ABSTRACT

Currently, multiple strategies have been proposed to guarantee better processes of super compensation for sports training, however, there is still no consensus due to the emergence of new knowledge related to interference processes related to concurrent training programs and their impact on the definition of strategies for sports planning. The objective of this work was to evaluate the explosive strength variables and their relationship with aerobic capacity as a tool to define sports planning strategies. A descriptive correlational study was carried out that included the participation of 6 amateur runners, valued in their aerobic capacity and explosive strength through the 2-kilometer running test and the Squat Jump (SJ), Counter Movement Jump (CMJ) and horizontal feet jump together (SH) respectively. The highest correlation found was between aerobic capacity and SJ jump ($p < 0.001$), which shows that aerobic capacity and muscular strength are fundamental pillars in training and athletic planning, in the same way, the non-existence of a relationship between the SH and the CMJ vertical jump ($p = 0.121$) allow establishing the practical importance of giving an emphasis to the development of aerobic capacity and specific strength in the horizontal running plane as an optimizing strategy that responds to sports performance in amateur runners.

Keywords: oxygen consumption; muscular strength; athletic performance.



RESUMEN

Actualmente se han propuesto múltiples estrategias que logren garantizar mejores procesos de supercompensación al entrenamiento deportivo, no obstante, aún no existe un consenso debido al surgimiento de nuevos conocimientos relacionados a los procesos de interferencia relacionados a programas de entrenamiento concurrente y su impacto sobre la definición de estrategias para la planificación deportiva. Este trabajo se planteó como objetivo evaluar las variables de fuerza explosiva y su relación con la capacidad aeróbica como una herramienta para definir estrategias de planificación de deportiva. Se realizó un estudio descriptivo correlacional que constó con la participación seis corredores aficionados, valorados en su capacidad aeróbica y fuerza explosiva mediante la prueba de carrera de 2 kms y los saltos Squat Jump (SJ), Counter Movement Jump (CMJ) y horizontal a pies juntos (SH) respectivamente. La mayor correlación encontrada fue entre la capacidad aeróbica y el salto SJ ($p < 0,001$), lo que demuestra que la capacidad aeróbica y la fuerza muscular son pilares fundamentales en el entrenamiento y planificación atlética, del mismo modo, la no existencia de una relación entre el SH y el salto vertical CMJ ($p = 0,121$) permiten establecer la importancia práctica de dar un énfasis al desarrollo de la capacidad aeróbica y fuerza específica en plano de carrera horizontal como una estrategia optimizadora que responde al rendimiento deportivo en corredores aficionados.

Palabras clave: consumo de oxígeno; fuerza muscular; rendimiento atlético.

RESUMO

Atualmente, foram propostas múltiplas estratégias para garantir melhores processos de sobre compensação na parte do treinamento esportivo, mas ainda não há consenso devido ao surgimento de novos conhecimentos relacionados com os processos de interferência relacionados com programas de treinamento simultâneos e seu impacto na definição de estratégias para o planejamento esportivo. O objetivo deste estudo foi avaliar as variáveis da força explosiva e a sua relação com a capacidade aeróbica como ferramenta para definir estratégias de planejamento desportivo. Foi realizado um estudo descriptivo correlacional com a participação de seis corredores amadores, que foram avaliados quanto à sua capacidade aeróbica e resistência explosiva por meio do teste de corrida de 2 km e do Salto de Agachamento (SJ), Salto de Contramarcha (CMJ) e Salto Horizontal a Pés (SH), respectivamente. A maior correlação encontrada foi entre a capacidade aeróbica e o salto SJ ($p < 0,001$), o que demonstra que a capacidade aeróbica e a força muscular são pilares fundamentais no treino e no planejamento atlético. Da mesma forma, a ausência de relação entre SH e CMJ salto vertical ($p = 0,121$) permite estabelecer a importância prática de dar ênfase ao desenvolvimento da capacidade aeróbica e da força específica no plano de corrida horizontal como estratégia de otimização que responde ao desempenho desportivo dos corredores amadores.

Palavras-chave: consumo de oxigênio; força muscular; desempenho atlético.

INTRODUCTION

Sports planning has currently proposed concurrent training as a means of directly impacting variables linked to health and sports performance related to a high component of specificity that involves maintaining a sequenced, timed and specific structure according to the characteristics of endurance sports and their athletes



(García-Manso., Arriaza-Ardiles., Valverde., Moya-Vergara., Mardones-Tare., 2017; Sánchez-López., & Rodríguez Pérez., 2017).

This type of program has been based on the fact that most sports specialties need to train both aerobic endurance and muscular strength in their different manifestations in order to improve sports performance and obtain greater effectiveness in the acquisition of beneficial adaptations compared to training both qualities separately (Flores-Zamora., 2019).

In this context, evidence has suggested that a high development of aerobic endurance seems to nullify the development and/or maintenance of muscle mass and strength due to the activation of the energy sensors of the protein kinase complex activated by AMP that favor mitochondrial adaptation and inhibit the activation of the markers of the mammalian target of rapamycin complex responsible for the activation of various anabolic processes induced by muscle strength exercises (Flores-Zamora A C, Rodríguez-Cedeño E M , Rodríguez-Blanco., 2017). Therefore, several strategies have been proposed in order to take advantage of the cumulative effect and guarantee a prolonged and stable adaptive phase linked to the different stimuli and physiological processes determining physical performance in endurance runners.

In this sense, multiple sports have postulated the development of sports performance optimization strategies based on separating the days dedicated to endurance training and the days dedicated to muscle strength training or, failing that, performing both types of training on the same day in a consecutive or separate manner with the aim of reducing the interference processes related to concurrent training programs. However, there is still no consensus on all these processes as a result of the heterogeneous results reported in various studies (Balsalobre-Fernández., Santos-Concejero., Grivas., 2016; Flores-Zamora., Rodríguez-Cedeño., Rodríguez-Blanco, 2017; Marcello, Greer, 2017; García-Manso *et al.*, 2017; Alcaraz-Ibañez, Rodríguez-Pérez, 2018; Gómez-Molina, Ogueta-Alday, Camara, Stickley, García-López, 2018; Flores-Zamora, 2019).

For this reason, the purpose of this study was to evaluate the variables of explosive strength and its relationship with aerobic capacity as a tool for defining sports planning strategies.

MATERIAL AND METHODS

Design and participants

A descriptive correlational study was conducted consisting of six adult amateur runners of both sexes, assigned to a single group classified as physically active, regular weight, and with no diagnosed or reported morbid history.

Inclusion criteria

The sample was chosen under non-probability criteria for convenience, due to the low sample number available the following inclusion criteria were considered.

- Age between 18 and 65.
- Level of physical activity over 150 min/week.
- Lower body mass index 24.9 kg/m².



- Waist circumference less than 88 for men and 83 for women.
- Alcohol consumption over 24 hours after a physical evaluation.
- No active tobacco habits.
- Have carried out physical activity 48 hours prior to the evaluation.
- Not present a history of cardiopulmonary diseases and acute or chronic musculoskeletal or systemic pathologies.
- Agree to voluntarily participate in the study and sign an informed consent authorizing the use of the information for scientific research purposes.

Procedure and instruments

This study was carried out in a single evaluation at the Mario Recordón athletic track in the Chilean National Stadium. The subjects were assigned to a single group, which was applied the international questionnaire for physical activity in its short version validated for Catalan population between 15 and 69 years (Román Viñas., Ribas Barba., Ngo., & Serra Majem, 2013), to this were added questions to investigate the history of cardiopulmonary diseases, musculoskeletal pathologies, acute or chronic systemic, in addition to information on the consumption of snuff and alcohol, therefore, participants were asked to avoid coffee consumption and present a fast of 2 hours and not exercise 24 h before the physical assessment.

Anthropometric assessment

The participants were measured and weighed to determine the body mass index and waist circumference of the participants according to the protocol of the World Health Organization (Labraña *et al.*, 2017), using for these evaluations the anthropometric kit brand CESCORF composed of a Seca digital balance with pressure of 100 gr, Seca portable stadiometer 220 cm and a tape measure with pressure of 1 mm.

Standardized warm-up

The physical evaluation began with a ten-minute general warm-up consisting of joint mobility; flexions, extensions, abductions and adductions of the shoulders, hips, knees and ankles, as well as a continuous jog without intensity control.

Jump capacity evaluation

- Squat jump: consists of a maximum vertical jump from a static position in bending the knees to 90° with the hands on the hips and the trunk straight, to later perform a vertical jump which ends when the athlete returns to the ground with the legs extended in plantar flexion and the arms fixed to the hip without any type of bounce or counter movement.
- Counter movement jump: it considers the same criteria as the SJ for its realization, it starts from an upright position from where a rapid movement of knee flexion-extension is performed up to an angle of 90° to then perform the jump.
- Horizontal jump to feet together: it starts with the feet aligned and slightly separated behind a delimited line from where the knees are bent to push the body towards the horizontal with the greatest possible power, finishing the jump when it falls to the ground.



These three jumps were performed on three occasions each, the SJ and CMJ being evaluated by means of a DM JUMP by Prometheus contact platform connected to the DMJ v 2.2 software, while the SH was evaluated with a CESCORF tape measure (López López, Martínez Cubides, & Acosta Tova., 2019).

Aerobic capacity evaluation

It was determined with the 2 km run test at the highest possible speed (Laukkanen, Oja, Parkkari, & Manttari, 2002), recording the maximum heart rate achieved with the Polar® H10 pulse monitor and the VO_2 peak with a Cosmed model K5 portable ergo spirometer, which was calibrated according to the manufacturer's recommendations.

Statistical analysis

Data were analyzed with SPSS 23.0 statistical software (SPSS 23.0 for Windows, SPSS Inc., IL, and USA). Data distribution was determined with the Shapiro-Wilk test. The Pearson correlation test was applied in order to relate the study variables considering an alpha level of 0.05 and a 95 % confidence interval. Finally, the variables studied were described with the following measures of central tendency and dispersion; mean, standard deviation, minimum, maximum, 25th percentile, 50th percentile and 75th percentile.

Ethical considerations

The research protocol was approved by the Ethics Committee of the Santo Tomas University's macro-zone center, folio 39.19, which considered this research to be risk-free in accordance with the ethical considerations stipulated in the Declaration of Helsinki of 2013.

RESULTS

The table 1 shows the descriptive statistics of the sample studied. Six adult runners aged 23 to 61 years, classified as physically active with normal weight (Body Mass Index <23.1) and without abdominal obesity (waist circumference less than 90 cm for men and 86 cm for women) participated. On the other hand, Vo_2 peak shows a similar mean value, while SJ, CMJ and SH report lower values compared to athletes (Ortiz, Denadai., Stella., & De Mello., 2003; Centeno-Prada *et al.*, 2015) (Table 1).



Table 1. - Statistical description of the characteristics related to health and sports performance in amateur runners in Santiago de Chile

Variables	Mean	Standard Deviation	Minimum	Maximum	Percentiles		
					25	50	75
Age (years)	40,1	15,2	23	61	26	37,5	56,5
Body Masa Index (kg/m ²)	23,1	1	21,5	24,1	21,9	23,4	23,9
Waist Circumference (cm)	77	5,6	65,8	81,2	74,1	79,3	79,9
Squat Jump (cm)	26,2	12,1	15,1	46,8	18,5	20,4	37,9
Counter Movement Jump (cm)	34,4	15,2	21,3	57	22,6	28	51,1
Horizontal jump on foot together (cm)	182,3	37,3	150	245,2	150,7	172,2	213,9
VO ₂ peak(ml/kg/min)	60,5	8,9	51,3	75,9	54,2	57,3	68,6

Years: period of 365 days, Kg/m²: kilograms per square metre, cm: centimetres, ml/kg/min: millilitre of oxygen used per kilogram of body weight in one minute.

In table 2, the results are shown in relation to the VO₂ peak as an indicator of aerobic capacity and the SJ, CMJ and SH jumps as indicators of jumping capacity. VO₂ peak correlates significantly with all indicators. On the other hand, the vertical jump capacity in SJ shows a significant positive relationship with CMJ and SH as an indicator of horizontal jump, while the horizontal jump capacity showed no relationship with CMJ as an indicator of vertical jump (Table 2).

Table 2. - Correlation values between jump capacity and VO₂ peak

	Heigth SJ	Height CMJ	Distance SH
Heigth SJ		$r=0,873$ $p=0,023$	$r=0,855$ $p=0,030$
Heigth CMJ	$r=0,873$ $p=0,023$		$r=0,701$ $p=0,121$
Distance SH	$r=0,855$ $p=0,030$	$r=0,701$ $p=0,121$	
VO ₂ peak.	$r=0,992$ $p<0,001$	$r=0,841$ $p=0,036$	$r=0,846$ $p=0,034$



DISCUSSION

The results shown in table 1 are similar to the VO_2 values established for endurance athletes, while the values in jumping capacity and elasticity index are lower than the expected values for a similar population of young adults and athletic practitioners (Ortiz, Denadai., Stella., & De Mello., 2003; Centeno-Prada *et al.*, 2015). These results can be explained based on the available scientific evidence, around the practice of activity and/or physical exercise of an aerobic type, practiced regularly around 150 minutes per week, is associated to positive adaptations on body composition and physical condition, since can generate a negative energy balance by inducing weight loss due to changes in insulin sensitivity, immune response, endogenous antioxidant systems and AMP-activated protein kinase, while endurance or muscle strength exercises have been associated with a synergistic effect in terms of improvements in aerobic capacity (Spinoza-Salines, *et al.*, 2020).

As for the VO_2 behavior, it reflects a good development of the aerobic capacity as a result of a training focused on this quality, while the lower values in the jumping capacity can be explained in part by the lack of hypertrophy characteristic of endurance runners. In this sense, it is known that aerobic work can cushion the development of hypertrophy by inducing lower levels of capacity to generate muscular strength and consequently higher levels of peripheral fatigue and decreases in running economy (Balsalobre-Fernández *et al.*, 2016; García-Manso *et al.*, 2017; Marcello *et al.*, 2017; Alcaraz-Ibáñez *et al.*, 2018; Gómez-Molina *et al.*, 2018; Flores-Zamora *et al.*, 2017; Flores-Zamora., 2019).

On the other hand, the results reported between aerobic performance and both vertical and horizontal jumps are consistent considering that VO_2 peak can be attributed to any activity in which there is a certain level of physical demand (Cade *et al.*, 2018).

The higher ratio of Squat Jump to VO_2 peak can be attributed to the fact that the SJ has a high muscle strength component, and it is therefore, considered a good indicator for both sports' performance and the level of neuromuscular fatigue caused by repeated high intensity exertion. In this regard, the literature has reported that a high level of strength expressed in SJ does not always guarantee better overall performance; This is due to the fact that specific training programs focused on strength development are the ones that bring improvements related to indicators such as race economy, peak VO_2 , recruitment capacity, synchronization of motor units and intra- and inter-muscular coordination, but not the strength level as such, while the low relationship between CMJ and SH can be justified by the influence of spatial-temporal parameters and the different neuromuscular adaptations linked to horizontal movements with slope or vertical movements generated by the race motor pattern (Ogueta-Alday., García-López., 2016).

Another possible explanation for the low relationship between CMJ and SH can be attributed to the little familiarity of those evaluated with performing both horizontal and vertical jumps. In this respect, the motor action involved in the jumps implies a predominance of a guiding quality that involves the technical characteristics of the movement, therefore, an adaptive integral reaction of the organism responds mainly to specific adaptations to the sporting gesture and not to the development of certain physical qualities, so that performance in medium and long distance races is determined by an overall motor capacity subordinated to muscular strength, due to which physical qualities do not usually appear in an abstract form but in combination with physical factors conditioning performance (Flores-Zamora., 2019).



Following this line of argument, Centeno-Prada *et al.*, (2015) postulate that the relationship between both types of jumps is directly influenced by the capacity and efficiency in the utilization of the viscoelastic components of the muscle-tendon system, since it is known that these can generate and store energy, which when used efficiently can improve jumping performance, In this context, the jumping capacity of CMJ like SH will depend not only on factors such as muscular strength expressed in the number of fast fibers and the capacity of recruitment of these, but also the coordination capacity reflected in the use of the muscular elastic reflex (González-Badillo, Jiménez-Reyes, Ramírez-Lechuga, 2017).

On the other hand, it has been observed that the intensity of the load is another fundamental factor related to the modulation of diverse adaptations linked to both muscular strength and aerobic capacity. In this respect, the evidence indicates in a global way that a plyometric strength program at a high intensity can affect the economy of running at moderate running intensities, so that no better long-term performance can be guaranteed, while a low intensity programme has demonstrated a high effect on physical performance based on improving running economy, peak speed and neuromuscular characteristics (Flower-Bloss., 2019).

In this context, the importance of concurrent training in the practice of aerobic endurance sports lies in the need to implement a well-planned and periodised training programme that considers the processes of interference between physical qualities with the aim of taking advantage of the cumulative effect and guaranteeing a prolonged and stable adaptive phase linked to the different stimuli and physiological processes that determine physical performance in endurance runners (Balsalobre-Fernández, Santos-Concejero, Grivas, 2016; Vorup *et al.*, 2016; Flores-Zamora, Rodríguez-Cedeño, Rodríguez-Blanco, 2017; Marcello, Greer, 2017 García-Manso *et al.*, 2017; Alcaraz-Ibáñez, Rodríguez-Pérez, 2018; Gómez-Molina, Ogueta-Alday, Camara, Stickley, García-López, 2018; Flores-Zamora, 2019).

Limitations of the study

This research is mainly limited in its external validity, since the selection of the sample was made for convenience, using a small sample. Likewise, these findings may be influenced by the wide age range and the non-separation of the sample by sex or age groups. On the other hand, some data such as smoking, alcohol consumption and disease history were obtained through self-reporting, which could lead to a risk of bias due to overestimation of unhealthy styles.

The findings reported in this population are indicative of a significant positive relationship between aerobic and jumping capacity. Thus, the practical importance of a training strategy that encompasses the development of aerobic and jumping capacity in parallel can be concluded by considering all interference processes related to concurrent training and athletic performance in amateur endurance runners.

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Conflict of interests:

The authors declare not to have any interest conflicts.

Authors' contribution:

The authors have participated in the writing of the work and analysis of the documents.



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