The execution velocity as a marker of metabolic health in university students

La velocidad de ejecución como marcador de la salud metabólica en estudiantes universitarios

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Abstract

The aim of this research was to evaluate execution velocity (EV) as a marker of metabolic health in university students. During the year 2020 and the first semester of 2021, a descriptive and cross-sectional study was carried out on 57 students (45 men and 12 women) belonging to a higher education institution located in the city of Bogotá, Colombia. To measure VE, the T-Force System, Ergotech, was used during the development of a direct protocol to determine the value of one repetition maximum (1RM) in the squat and bench press exercise. To assess the metabolic profile, a blood sample was taken, which was deposited in the Cardiocheck equipment with which total cholesterol, triglycerides, high-density lipoproteins (HDL), low-density lipoproteins (LDL), and glucose levels. Participants who developed a lower average mean propulsive speed in all the series developed, both in the squat test and in the flat press exercise, presented a higher Metabolic Risk Score compared to those who had a better performance (p < .001).

Keywords: Muscle strength, metabolic alterations, risk predictor, propulsive speed.

Resumen

El objetivo de esta investigación fue evaluar la velocidad de ejecución como marcador de la salud metabólica en estudiantes universitarios. Durante el año 2020 y el primer semestre del 2021, se desarrolló un estudio descriptivo y transversal, en 57 estudiantes (45 hombres y 12 mujeres) pertenecientes a una institución de educación superior ubicada en la ciudad de Bogotá, Colombia. Para la medición de la velocidad de ejecución (VE) se utilizó el sistema T-Force System, Ergotech durante el desarrollo de un protocolo directo para determinar el valor de una repetición máxima(1RM) en los ejercicios de sentadilla completa libre y press banca. Para la valoración del perfil metabólico se realizó la toma de una muestra sanguínea la cual se depositó en el equipo Cardiocheck con el que se determinó el colesterol total, triglicéridos, lipopreteinas de alta densidad (HDL), lipoproteínas de baja densidad (LDL), y los niveles de glucosa. Los participantes que desarrollaron una velocidad media propulsiva promedio menor en la totalidad de las series desarrolladas, tanto en la prueba de sentadilla como en el ejercicio de press plano, presentaron un Score de riesgo metabólico más alto en comparación con los que tuvieron un mejor desempeño (*p* < .001).

Palabras clave: Fuerza muscular, alteraciones metabólicas, predictor de riesgo, velocidad propulsiva.

Introduction

Chronic non-communicable diseases (NCDs) are long-term conditions and represent the leading cause of death worldwide, accounting for 63% of the total annual deaths (Nawsherwan et al., 2023). In Colombia, a recent study conducted on 7,485 subjects aged 35 to 70 years found that the self-reported prevalence of NCDs was 29.7%; nearly one in four Colombian adults suffers from this problem (Camacho et al., 2020). The prevalence of these pathological conditions is mainly attributed to the presence of risk factors associated with unhealthy lifestyles (Allen et al., 2017). In this regard, engaging in physical activity and maintaining a balanced nutrition are behaviors that can prevent the onset of these diseases (Yusuf et al., 2004).

The university environment has become a setting where young people adopt unhealthy lifestyles. One of the factors contributing to this trend is the academic workload and the various responsibilities that come with this stage of life, leading to sedentary habits and poor dietary choices that adversely impact health (Ortiz et al., 2020). A concerning aspect of this situation is that a significant portion of young individuals seem indifferent to the potential consequences of these behaviors on their health. This indifference is largely fueled by misinformation and the belief that it's challenging to develop any non-communicable diseases at their age. However, it is precisely during this stage that metabolic alterations begin to occur, increasing the likelihood of developing these conditions in adulthood.

This issue highlights the necessity within epidemiological monitoring systems to identify and implement simple and practical tests for evaluating the potential risk that young individuals face in developing NCDs in their later years (Stamatakis et al., 2019). In this context, the assessment of health-related physical condition (CFRS) emerges as an alternative that enables the indirect determination of certain metabolic alterations young people might be experiencing through field tests. Numerous studies, both nationally and internationally, have established that muscle strength serves as an indirect indicator of health across all age groups and is an independent predictor of future illnesses in the youth population (Ramírez-Vélez et al., 2020). Most of these investigations have employed straightforward measurement techniques like grip strength and longitudinal jumps (Cohen et al., 2014).

However, there is a methodology for measuring force that asserts the only way to directly evaluate it is by understanding the speed at which external loads move (González-Badillo & Sánchez-Medina, 2010). In this context, the concept of applied force has been proposed as a means to assess the extent to which the internal tension generated by muscles upon activation is externally manifested. Presently, in the Colombian context, a knowledge gap exists as no research was found in the literature review that independently assesses how the execution speed in muscular exercises can be indicative of the health status of the young adult population. Based on the aforementioned, the research question of this study was: What is the relationship between execution velocity and metabolic risk in a sample of university students from the city of Bogotá?

Methodology

Design and participants

During the year 2020 and the first semester of 2021, a descriptive and cross-sectional study was conducted on 57 students (45 men and 12 women) from a higher education institution in Bogotá, Colombia. The sample selection was based on non-probabilistic convenience sampling. Inclusion criteria were defined as being an active university student between 18 and 30 years old, having studied at least three consecutive semesters at the institution, being physically active as determined through the IPAQ questionnaire (consuming more than 1,500 METs weekly) (Arango-Vélez et al., 2020), and having a minimum of one year's experience in strength training. Participants who answered "yes" to any question on the PAR-Q questionnaire (Warburton et al., 2021) or reported any physical disability preventing them from participating in the strength measurement protocols were excluded. The study was designed following the deontological standards outlined in the Declaration of Helsinki and Resolution 008430 of 1993 of the Ministry of Health of Colombia, regulating clinical research involving humans. Ethical approval was obtained from the ethics committee of the Andean Area University Foundation (code: CVF2020-IM-B02).

Instruments and procedures

All participants were informed about the research objective and the applied protocols. Subsequently, they signed informed consent forms and were scheduled for the following procedures.

Body Composition

This variable was assessed using segmental bioelectrical impedance analysis with the Tanita IRONMAN BC-1500 scale. The protocol involved standing on the equipment, holding the hands and extending them forward for eight seconds. Participants were required to fast for at least 8 hours and empty their bladder at least one hour before the test. Evaluations were conducted in the morning, with an empty bladder, on a non-conductive surface. Waist circumference and hip circumference were measured with a SECA model 203 measuring tape, following anatomical references described by the International Society for the Advancement of Kinanthropometry (Wentz, et al., 2022).

Execution velocity

To measure this variable, a direct protocol was applied to determine the value of maximum repetition in full free squat and bench press exercises. The velocity of execution of each repetition was evaluated with the T-Force System, Ergotech. The initial load was set at 20 kg, with progressive increments of 10 kg until the mean propulsive velocity (VMP) was < 0.8 m·s^{-1}. Smaller increments (5 to 2.5 kg) were made from this limit. Three repetitions were executed when VMP was ≥ 0.8 m·s^{-1}, two when it was between 0.8 m·s^{-1}and 0.5 m·s^{-1}, and one when it was < 0.5 m·s^{-1}. Participants were verbally encouraged to exert maximum effort. There was a 2-minute recovery between sets. Only the best repetition in each series, based on the fastest VMP, was considered. Each execution was performed in a controlled manner during the eccentric phase and at maximum speed during the concentric phase. The warm-up consisted of 5 minutes of joint mobilization exercises related to the involved joints in these exercises. The assessment started with the evaluation of one maximum repetition in the bench press exercise and then the squat exercise for all subjects.

The T-Force System, Ergotech, is a measurement system that automatically calculates the velocity of each repetition and provides real-time auditory feedback. This system includes a linear velocity transducer interfaced to a personal computer using 14-bit resolution, a digital data acquisition board, and custom software for data storage and analysis. The reliability and validity of this equipment have been verified in various studies (Gómez-Píriz et al., 2011).

Metabolic risk

The biochemical sample was collected between 6:00 and 9:00 in the morning by a nurse and two specialists in physical exercise for health with extensive experience in this type of measurements. All participants had to report fasting for more than 12 hours. The procedure for taking the blood sample was developed by applying the following steps: 1) the finger was cleaned with alcohol until it was completely dry 2) with a new and sterilized lancet, a puncture was performed on the index finger, the first drop was collected. It was cleaned with gauze and the second was collected in a pipe and then introduced into the reagent. Triglyceride, total cholesterol, HDL, LDL, and glucose levels were measured by colorimetric enzymatic methods with the use of a Cardiocheck analyzer.

Statistical analysis

Before the planned statistical analyses, a preliminary test was performed to check the normality (Kolmogorov-Smirnov) of the data distribution. A T test for independent samples was applied to compare differences in continuous variables by sex. In addition to calculating the one repetition maximum value for the squat and bench press exercises, the following variables were included: i) average achieved in all the series developed (VMP), 2) average VMP achieved against fast loads (series developed at a VMP ≥ 0.1 m·s^{-1}) 3) average VMP achieved against slow loads (series developed at a VMP ≤ 0.1 m·s^{-1}). Subsequently, the variables of total cholesterol, triglycerides, LDL and glucose were reconfigured as, Z = ([value – mean]/standard deviation). The HDL variable was multiplied by [–1] because its relationship with cardiovascular risk is opposite to the rest. The metabolic risk index was calculated as the sum of the five typed variables. The results of the average VMP variable achieved in all the series developed were recoded into quartiles, with the quartile (Q1) being the position with the lowest performance. Finally, a one-factor ANOVA was applied to establish the relationship between metabolic risk and performance in the execution speed test, recoded into quartiles, adjusting it with fat percentage and muscle percentage as possible confounding variables. Statistical significance was established at $p < .005$. All analyzes were performed using IBM Statistical Analysis SPSS Statistics version 24.0 (Chicago, IL, USA).

Results

Table 1 shows the general characteristics of the sample; it is evident that in the variables of weight, height and % fat there were significant differences by gender (P < .005). On the other hand, in biochemical tests, the results were similar in both men and women (P ≥ .005). Finally, in the EV tests, the performance of men was superior compared to women (P < .005).

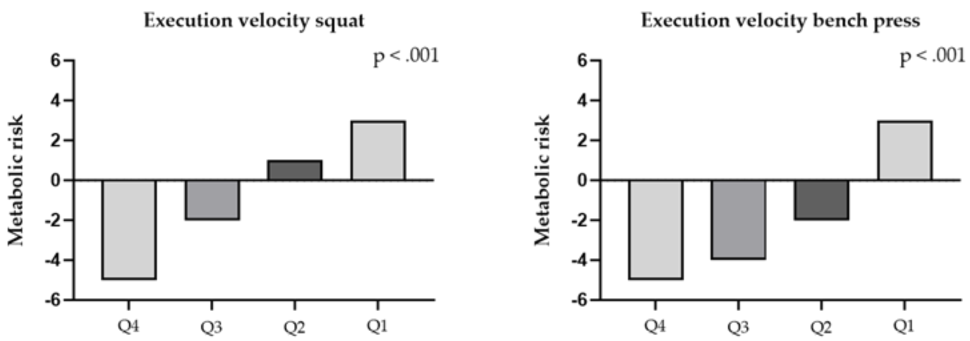

Figure 1. Relationship between execution velocity and metabolic risk

Table 1. General characteristics of the sample

Characteristics	Men (n = 45)	Women (n = 12)	*p value*
Age (years)	19.57 (2.2)	18.66 (0.77)	.177
Body composition			
Weight (kg)	66.2 (9.4)	54.06 (4.5)	< .001 *
Height (cm)	172.0 (6.2)	156.8 (4.4)	< .001 *
BMI (kg·m-2)	22.28 (2.28)	22 (2.04)	.696
Fat (%)	13.2 (4.0)	20.4 (4.2)	< .001 *
Visceral fat (1-20)	1.73 (1.3)	1.16 (2.5)	.110
Metabolic age (years)	15.08 (6.4)	12 (2.1)	.140
Waist circumference (cm)	75.02 (6.3)	70.2 (4.7)	.019
Hip circumference (cm)	93.2 (5.2)	90.68 (4.2)	.130
Biochemical variables			
Total cholesterol (mg/dL)	133.1 (23.7)	142.1 (33.8)	.731
Triglycerides (mg/dL)	88.9 (33.12)	93.1 (20.5)	.633
HDL (mg/dL)	47.4. (10.1)	45.2 (7.4)	.732
LDL (mg/dL)	74.8 (15.3)	77.6 (10.9)	.832
Glucose (mg/dL)	88.2 (7.3)	84.6 (5.1)	.523
Metabolic risk	-0.37 (3.1)	-0.27 (2.5)	.734
Muscular strength			
Squat 1RM (kg)	73.11 (13.7)	53.33 (9.8)	< .001 *
Bench Pres 1RM (kg)	39.3 (21.06)	21.6 (7.1)	< .001 *
Execution velocity			
Squat MVP ($m \cdot s^{-1}$)	0.89 (0.22)	0.75 (0.09)	.032 *
Fast Loads Squat MVP ($m \cdot s^{-1}$)	1.08 (0.22)	0.94 (0.09)	.023 *
Slow Loads Squat MVP ($m \cdot s^{-1}$)	0.74 (0.22)	0.6 (0.09)	.046 *
Bench Press MVP ($m \cdot s^{-1}$)	0.73 (0.22)	0.59 (0.09)	.036 *
Fast Loads Bench Press MVP ($m \cdot s^{-1}$)	0.92 (0.22)	0.78 (0.09)	.045 *
Slow Loads Bench Press MVP ($m \cdot s^{-1}$)	0.58 (0.22)	0.44 (0.09)	.028 *

Data are expressed as mean and standard deviation. *Significant differences between groups for Student's t test

Figure 1 shows that the participants with the lowest performance in the average MPV test achieved in all the series developed, both in the squat test and the flat press test (Q1), presented a higher metabolic risk score. compared to the best performers (Q4) (P < .005).

Discussion

The main finding of this research was that participants who shifted the loads to a higher EV, both in the squat and bench press exercise, had a lower metabolic risk index. Our results suggest that this is a component of physical condition that is valid to indirectly determine metabolic health in young university students.

In the international context, EV is a training component that has gained importance in the programming of strength training in sports such as weightlifting, since it facilitates different processes such as the real-time assessment of the applied force (Rodríguez-Rosell et al., 2021), however, these concepts taken to the context of health, is a topic in which no research has been proposed. The closest to this problem are the studies that have determined, in older adults, that tests such as walking velocity have a predictive capacity for adverse health events such as falls, hospitalization periods, and mortality from NCDs (Binotto et al., 2018). It has also been shown that protocols such as Timed Up-and-Go which evaluates maximum velocity, is an indicator of a person's functionality and is associated with their lipid-metabolic profile (do Carmo Correia et al., 2019). Despite this, the biomechanical and physiological principles of these protocols are totally different from those we developed in our study, mainly because the one we proposed seeks to evaluate how a person overcomes an external load in the shortest possible time through internal tension. generated by the muscle. In Colombia, research has been developed that shows that strength, evaluated through protocols such as grip dynamometry and one repetition maximum tests, is significantly associated with different health markers such as glucose levels, triglycerides, total cholesterol and body composition components such as muscle and fat percentage (Garcia-Hermoso et al., 2019; Ibagon et al., 2021); However, none of these studies analyzed strength taking VE as a reference, which is why the results of our study generate an innovative and novel contribution to the national context.

One of the explanations why those young people with better performance in the proposed tests have better metabolic health is based on the release of myokines, which are released during muscle contraction and favor different processes such as fat oxidation, uptake of glucose by cells, increased insulin sensitivity and increased anti-inflammatory activity (Gonzalez-Gil & Elizondo-Montemayor, 2020).

One of the main limitations of this research was that since it is a cross-sectional study, causal relationships between the variables cannot be established. For this reason, it is proposed that future research establishes under an experimental design how a strength training program programmed from EV can improve some metabolic markers in young adults. On the other hand, when selecting the sample using a non-probabilistic method for convenience, the results cannot be extrapolated to the entire population.

Conclusions

The main conclusion of this research was that EV serves as an indirect marker of health in university students. In this sense, those students who moved the loads to a greater EV, both in the squat and press exercise, presented healthier metabolic test values compared to those who moved the weights more slowly.

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