

Nivel de actividad física relacionado con el estado de ánimo, el control neuromuscular y la fuerza en jóvenes atletas no profesionales

Level of physical activity related to mood, neuromuscular control, and strength in non-professional young athletes

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Resumen. El objetivo de este estudio fue analizar el nivel de actividad física, el perfil del estado de ánimo, el control neuromuscular y la manifestación de la fuerza en atletas adolescentes no profesionales. Una muestra de 24 voluntarios sanos participó en el estudio. Cada sujeto cumplimentó el Cuestionario Internacional de Actividad Física (IPAQ) y el cuestionario Perfil de Estados de Ánimo (POMS). Posteriormente, se realizó una evaluación utilizando un protocolo de carga incremental para determinar el máximo de una repetición en el ejercicio de press de banca. Después de cada serie, se evaluó la fuerza en función de la carga total, la velocidad de propulsión media y la percepción subjetiva del esfuerzo. Además, se aplicó la prueba de golpeteo con los dedos (FTT) como medida de control motor, y se realizó una segunda evaluación de la fuerza utilizando un dinamómetro manual. Los resultados mostraron una diferencia significativa en las fases de golpeteo del FTT al principio y al final del protocolo. Se encontraron datos significativos en el conjunto máximo respecto a la relación entre la carga total, la velocidad media de propulsión y la fuerza de prensión de la mano. Estos resultados apoyan el uso del FTT y del dinamómetro manual como medidas para controlar las fases del entrenamiento de fuerza en términos de carga aplicada y tiempo de recuperación.

Palabras clave: Nivel de actividad física, Finger Tapping Test, estado de ánimo, fuerza, control neuromuscular.

Abstract. The aim of this study was to analyze the level of physical activity, mood profile, neuromuscular control, and strength manifestation in non-professional adolescent athletes. A sample of 24 healthy volunteers participated in the study. Each subject completed the International Physical Activity Questionnaire (IPAQ) and the Profile of Mood States (POMS) questionnaire. Subsequently, an evaluation was conducted using an incremental load protocol to determine the one-repetition maximum in the bench press exercise. After each set, strength was assessed based on total load, mean propulsive velocity, and subjective perception of effort. In addition, the Finger Tapping Test (FTT) was implemented as a measure of motor control, and a second strength assessment was performed using a manual dynamometer. The results showed a significant difference in the tapping phases of the FTT at the beginning and end of the protocol. Significant data were found in the maximum set regarding the relationship between total load, mean propulsive velocity, and handgrip strength. These results support the use of the FTT and manual dynamometer as measures to control the phases of strength training in terms of applied load and recovery time.

Keywords: Physical activity level, Finger Tapping Test, mood, strength, neuromuscular control.

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Introduction

The expression of strength in an individual is a multifaceted phenomenon that has been the subject of study in recent years (Steele, Fisher, Assunção, Bottaro & Gentil, 2017). Various factors influence this capacity, with one of the most determining factors being the individual's state, which is influenced by variables such as the level of activation, neuromuscular development, mood, perceived effort, and others (Barahona-Fuentes, Huerta-Ojeda & Chiroso-Ríos, 2021).

To quantify the exercise intensity in a strength training program, it is essential to consider a series of parameters, including the total number of sets and repetitions, the percentage of one-repetition maximum (1RM), rest intervals between sets, the order of exercises, and the speed of load execution (Cormie, McGuigan & Newton, 2011; Fleck, 1999). Although electronic devices have been developed to measure variables such as strength, power, and speed (Harris, Cronin, Taylor, Boris & Sheppard, 2010), their high cost and resource requirements make subjective effort rating scales widely used tools for controlling training intensity (Ozkan & Kin-Isler, 2007; Tiggemann, Korzenowski,

Brentano, Tartaruga, Alberton, & Kruehl, 2010). These scales not only allow quantification and monitoring of training but also provide valuable information about the sensations perceived by the athlete, which can help coaches adjust intensity in different training sessions.

In this context, the use of subjective perceived effort, through the rate of perceived exertion (RPE) index (Borg, 1992), has become common in training programs. RPE is based on athletes' intrinsic ability to control physiological stress during training, allowing them to adjust their intensity based on their own perception of effort (Robinson, Robinson, Hume, & Hopkins, 1991). Compared to other measures such as heart rate or blood lactate concentration, RPE has been shown to be a valid measure of exercise intensity (Borresen & Lambert, 2009; Foster, 1998). Therefore, its use in assessing changes in training volume and stress during training can provide valuable information about the athletes' status, allowing coaches to prevent overtraining or excessive fatigue situations (Elloumi, Makni, Moalla, Bouaziz, Tabka, Lac, & Chamari, 2012).

The type of training not only has physical but also psychological implications. For example, athletes' mood can be influenced by the type of training performed (Torres-

Luque, Hernández-García, Olmedilla, Ortega, & Garatachea, 2013). Psychological changes are often consistent with physiological indicators (Bonete, Moya, & Suay, 2009), so their control is fundamental. Questionnaires have become popular tools for assessing these psychological changes due to their ease of administration, cost-efficiency, and flexibility to be applied before, during, or after training or competition.

A widely used questionnaire to assess the psychological effects of training and competition on athletes is the Profile of Mood States (POMS) (Andrade, Arce, Seoane, 2000; De la Vega, Ruiz, García-Más, Balagué, Olmedilla, & Del Valle, 2008). This mood state profile assessment instrument has been used in both adult and adolescent athletes, allowing researchers to examine the relationship between mood and the athlete's current situation. Furthermore, individuals engaging in regular physical activity have been shown to experience psychological benefits, such as an increased sense of well-being and improved mood (O'Neil, Dunn, & Martinsen, 2000).

In a previous study (Torres-Luque, García, López-Baraja, Hernández-García, & Nikolaidis, 2018), the relationship between two psychological variables, perceived effort, and mood profile was explored. An 8-week training program was conducted in non-athlete adults to assess the possible correlation between training volume, perceived effort, and mood profile. Both variables proved to be sensitive indicators of how training loads affect individuals. However, it is important to note that there was no apparent relationship between subjective perceived effort and tension and depression factors. Regarding neuromuscular control, the Finger Tapping Test (FTT) has been used as a sensitive test to assess speed and motor control not only in athletic populations, but also in diseases such as fibromyalgia (Brígida, Catela, Mercé, & Branco, 2024). The relationship between age and performance in the FTT has been recognized in previous studies (Bornstein, Paniak, & O'Brien, 1987), and it has been observed that men tend to perform better in tests of fine motor strength and speed compared to women (Leckliter & Matarazzo, 1989). The FTT has been used in the sports context to detect talent in artistic gymnastics (López & Vernetta, 1997) and has been cited in research on psychological control of training in high-performance athletes (Chaabouni, Methani, Al Hadabi, Al Busafi, Al Kitani, Al Jadidi, Samozino, Moalla, & Gmada, 2022). Despite the usefulness of the FTT in various contexts, there is not enough evidence on whether this test is discriminatory regarding a recreational adolescent athlete population. Given the lack of information available about the relationship between all these variables, this experimental study is conducted to obtain new evidence of correlation between neuromuscular control, perceived effort, strength manifestation, and mood in young recreational adolescent athletes.

Methodology

Design

The research design used in this study is quantitative,

where numerical data on the analyzed variables were collected. Additionally, it is non-experimental, as there were neither experimental nor control groups, and variables were not manipulated through the application of any intervention. Furthermore, the study was descriptive, detailing the characteristics and phenomena reported by the participants in each of the tests used. Additionally, the study is correlational, identifying relationships between each of the analyzed variables. Finally, the study is cross-sectional, collecting data at the specific moment when the phenomena being evaluated were manifested.

Participants

The sample consisted of 24 subjects (54% males and 46% females), with a mean age of 21.12 years (± 2.72). Participants voluntarily enrolled in the present study. The study utilized a non-probabilistic convenience sampling approach. Table 1 summarizes the characteristics for age, weight, height, RM, and RM/Body Weight ratio (RM/BW).

Table 1.
Demographic Data of the Sample

Variables	Mean	SD
Age (years)	21,125	2,723
Height (cm)	175,237	7,647
Body Weight (kg)	75,429	11,143
RM (kg)	60,958	20,167
RM_Body Weight	0,805	0,220

Data in mean and SD; RM: Total weight lifted in the bench press one-repetition maximum (1RM); RM_Body Weight: Ratio of 1RM to Body Weight.

Instruments

The abbreviated Spanish version of POMS published by Andrade, Arce, De Francisco, Torrado, & Garrido (2013) was used, consisting of 30 items representing six conceptual dimensions: Anger, Fatigue, Vigor, Friendship, Tension, and Depression (5 items for each factor). The response format was the usual five ordered categories, to which values between 0 (not at all) and 4 (very much) were assigned.

The Finger Tapping Test (FTT) was conducted using a freely available application on the Android platform for mobile devices (Tap Test Pro).

An electronic hand dynamometer was used to measure manual grip strength.

A portable digital scale was used for measuring body weight.

The bench press exercise was performed on a traditional bench press machine (Gimnasio Formas, Seville, Spain) properly calibrated for evaluation. The total weight of the bar without plates was 12 kg. For evaluating the average propulsive velocity of each repetition in the incremental protocol, a linear displacement device (DDL) was used (ChronoJump, Barcelona, Spain). The system consists of a cable adapted to the bar, and the displacement information is recorded, after passing through a data acquisition card, on a personal computer.

Procedure

Prior to the research, each participant signed an

informed consent form in accordance with the Declaration of Helsinki. In this document, they were informed about the risks and benefits of the research.

Subsequently, the assessment of the mood profile was conducted using the POMS questionnaire, and the level of physical activity performed in the last week was assessed using the IPAQ questionnaire. Regarding the POMS, the researchers followed a standard protocol to ensure that all participants received the same instructions. This protocol included the request to "circle the number that best describes how you feel right now." The phrase "how you feel right now" was used, considering the ephemeral nature of mood and the preference for recording current sensations rather than a daily or weekly summary (Lane & Terry, 2000).

Weight and height data were then collected. A portable digital scale was used to determine weight, and the height was measured using the pull-up method.

Subsequently, a standardized and specific warm-up for the bench press was performed, starting with 5 minutes on a stationary bicycle at 50W of power. Then, a familiarization with the bench press technical gesture was conducted, ending with 3 sets of 15 repetitions without load. The grip was standardized unilaterally using the distance from the epicondyle measurement to the jugular notch (Figure 1).

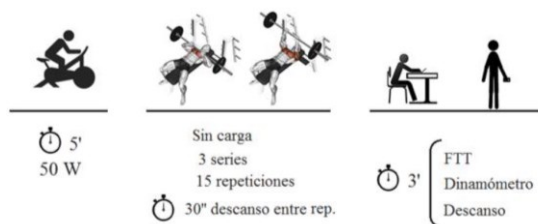


Figure 1. Representation of the warm-up before starting the assessment.

Subsequently, the FTT was conducted. The FTT was presented to the participants, and they were explained what it consisted of, stating the following: "Tap the screen with the index finger of your dominant hand at a pace that you consider comfortable for 10 seconds while looking at a fixed point in front of you. After this time, the screen will deactivate, and you will need to repeat the same process but at a fast pace, then normal, and finally slow." Then, any doubts were clarified, and the participants were allowed to perform a practice trial. Afterward, the test was conducted, and the recorded data were stored.

Next, an electronic hand dynamometer was used, which the participants had to hold with their dominant hand using the first phalanges and the heel of the hand. The arm remained extended, and the effort was sustained for 3 seconds.

To conclude, an incremental load protocol was carried out to reach the 1RM, following the methodology of Baechle, Earle, and Wathen (2000). Each subject performed independent sets with load increases of 10 kg, except for the last sets, where load increases of 4 kg to 1 kg

were determined. To avoid the neural fatigue effect, recovery periods of 3 to 5 minutes were allowed. The shorter rest periods (3 minutes) were given when load increases were 10 kg, while the longer rest periods (5 minutes) were for load increases of 5 kg or less. The repetitions set for the first set with the initial load were 8 (equivalent to 50% of the estimated 1RM that each subject thought they could lift from a maximum effort of a single repetition (estimated 1RM)). The load increase in subsequent sets led to a decrease in the number of repetitions until finishing with a single repetition (1RM). The technique described by Escamilla, Lander, and Garhammer (2000) was followed. Subjects were instructed to perform the concentric phase as quickly as possible, and the descent was controlled during the eccentric phase, lowering the bar until it touched the chest to avoid a rebound action when reversing the direction of movement. After an acoustical signal with randomized timing to prevent counter-movement actions, the subject moved the bar at maximum speed. The rest intervals between sets were used to repeat the FTT and the manual grip strength test with the dynamometer, as well as to ask the subject about their perception of effort using the Borg scale (values between 1 and 10) (Figure 2).

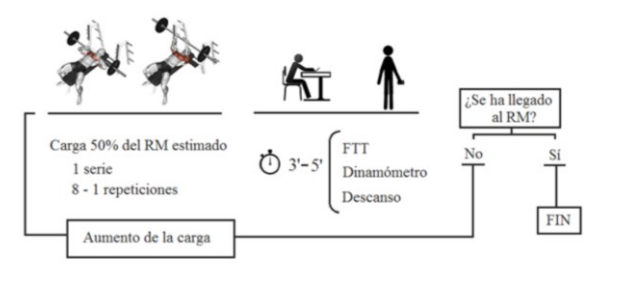


Figure 2. Representation of the assessment protocol.

Data Analysis

The present project conducted statistical analysis using the SPSS software version 20.0. First, a normality analysis of the variables was performed, followed by a descriptive analysis of each of the variables along with the standard deviation. On the other hand, the comparison between means was carried out using the Student's t-test. Finally, a bilateral correlation analysis was conducted using Pearson's correlation coefficient.

Results

Table 2 summarizes the descriptive data for the different mood dimensions.

Table 2.
Descriptive data in mood states

Variables	Mean	SD
Anger	0,416	0,513
Tension	1,225	0,885
Fatigue	2,266	0,991
Vigor	3,300	0,656
Friendship	0,9333	1,007
Depressed state	0,4833	0,947

Data in mean and SD

As can be observed, the positive mood factor (vigor) obtained the highest mean value. The second highest value reached was fatigue (2.26 ± 0.99). On the other hand, both tension and the friendship dimension obtained similar values (1.22 ± 0.88 , 0.93 ± 1.00 , respectively). Finally, the dimension with the lowest value represented was anger (0.41 ± 0.51).

Table 3 displays the data related to the level of physical activity assessed using the IPAQ test, expressed in METs.

Table 3.

Descriptive data in physical activity

Physical Activity	Mean	SD
Walks (meters)	1223,062	189,4177
Moderate Physical Activity (meters)	1190	240,175
Vigorous Physical Activity (meters)	2360	257,694

Data in mean and SD; Walks: Household chores, getting around, recreational walking, sports, exercise, or leisure walking. Moderate Physical Activity: Carrying light objects, cycling at a regular pace, etc. Vigorous Physical Activity: Lifting heavy objects, digging, aerobic activities, or fast cycling.

The results show a higher value of vigorous physical activity compared to moderate physical activity and walking. Table 4 provides descriptive data for the variables that were assessed during warm-up and familiarization.

Table 4.

Descriptive data in FTT and dynamometer

VARIABLES	Mean	SD
Cal_FTT_NORMAL (pulsations)	17,708	5,536
Cal_FTT_FAST (pulsations)	51,458	13,73
Cal_FTT_NORMAL_2 (pulsations)	17,791	5,477
Cal_FTT_SLOW (pulsations)	10,375	2,601
Cal_DYNAMOMETER (kg)	40,766	9,548

Cal_FTT_NORMAL: Number of taps at normal pace in the Finger Tapping Test during warm-up; Cal_FTT_FAST: Number of taps at fast pace in the Finger Tapping Test during warm-up; Cal_FTT_NORMAL_2: Number of taps in the second normal pace in the Finger Tapping Test during warm-up; Cal_FTT_SLOW: Number of taps at slow pace in the Finger Tapping Test during warm-up; Cal_DYNAMOMETER: Amount of force exerted on the hand dynamometer (Kg.) during warm-up.

We can see that the first and third phases of the FTT (normal rhythm) show very similar values.

In addition to providing descriptive data, this study also conducted comparisons between variables. Table 5 provides detailed comparative data for the assessments related to the FTT during warm-up and the maximum series (1RM).

Table 5.

Significant differences between variables of the FTT during warm-up and at maximum effort.

VARIABLES	p
Cal_FTT_NORMAL - Serie_MAX_FTT_FAST	0,142
Cal_FTT_FAST - Serie_MAX_FTT_FAST	0,410
Cal_FTT_NORMAL_2 - Serie_MAX_FTT_NORMAL_2	0,046*
Cal_FTT_SLOW - Serie_MAX_FTT_SLOW	0,002*

Cal_FTT_NORMAL - Serie_MAX_FTT_NORMAL: Comparison of the results of normal-paced tapping in the warm-up and the maximum series (RM); Cal_FTT_FAST - Serie_MAX_FTT_FAST: Comparison of the results of fast-paced tapping in the warm-up and the maximum series (RM); Cal_FTT_NORMAL_2 - Serie_MAX_FTT_NORMAL_2: Comparison of the results of the second normal-paced tapping in the warm-up and the maximum series (RM); Cal_FTT_SLOW - Serie_MAX_FTT_SLOW: Comparison of the results of slow-paced tapping in the warm-up and the maximum series (RM); $p \leq 0.05$.

Comparing the evaluated data, significant differences

have been found in the second pulse at a normal rhythm during warm-up and the maximum series, as well as in the slow rhythm pulse during warm-up and the maximum series. The data comparing the evaluations of the Finger Tapping Test (FTT) in the first series and the maximum series (1RM) are detailed in Table 6.

Table 6.

Significant differences between variables of FTT in series 1 and in maximum series.

VARIABLES	p
Serie_1_FTT_NORMAL - Serie_MAX_FTT_NORMAL	0,007*
Serie_1_FTT_FAST - Serie_MAX_FTT_FAST	0,186
Serie_1_FTT_NORMAL_2 - Serie_MAX_FTT_NORMAL_2	0,809
Serie_1_FTT_SLOW - Serie_MAX_FTT_SLOW	0,26

Serie_1_FTT_NORMAL - Serie_MAX_FTT_NORMAL: Comparison of results of normal rhythm pulsation in series 1 and maximum series (RM); Serie_1_FTT_FAST - Serie_MAX_FTT_FAST: Comparison of results of fast rhythm pulsation in series 1 and maximum series (RM); Serie_1_FTT_NORMAL_2 - Serie_MAX_FTT_NORMAL_2: Comparison of results of the second normal rhythm pulsation in series 1 and maximum series (RM); Serie_1_FTT_SLOW - Serie_MAX_FTT_SLOW: Comparison of results of slow rhythm pulsation in series 1 and maximum series (RM); Significance level: $p \leq 0.05$.

The variable of pulsation at a normal rhythm shows a significant difference when evaluated at the beginning of the incremental test (Series 1) and at the end (Maximum series).

Regarding the strength evaluated using a manual dynamometer, no significant differences are observed between the strength values exerted with the dynamometer evaluated during warm-up and the maximum series. Finally, in Table 7 (Supplement A), the correlations between mood, the assessment of physical activity level, the RM/body weight ratio, and the parameters recorded during the maximum series are presented. Observing the table, we can see that moderate physical activity and total activity are directly proportional to the vigor factor. On the other hand, the total load in the maximum series is inversely proportional to the maximum propulsive average velocity in that series. Regarding the FTT data, there is a very strong direct correlation between the two series of normal pulsations and the slow pulsation series in the maximum series. In addition, there is a direct correlation between the slow pulsation series and the anger and depressed state factors. Finally, we observe a positive correlation between the dynamometer data in the maximum series, fatigue, and total load.

Discussion

The purpose of this study was to investigate the influence of mood on neuromuscular control and strength manifestation, as well as how this neuromuscular control affects the expression of maximum strength, expressed through bench press and manual dynamometer.

We can find in the literature a large number of studies focused on the athlete population (Hernández, Torres-Luque & Olmedilla, 2009; Torres-Luque, Hernández-García, Olmedilla, Ortega & Garatachea, 2013), which seek maximum performance, compared to the non-athlete population (Torres-Luque, García, López-Baraja,

Hernández-García & Nikolaidis, 2018). Furthermore, these studies focus on evaluating these variables over a training period. Based on this, we can say that one of the greatest contributions of our study is to show the relationships between these variables at a specific moment in a common population with similar characteristics. In this way, the individual is not influenced by other external factors, as data collection comprises a single session in which their progression is observed throughout an incremental bench press test. Regarding mood dimensions, we paid special attention to the vigor factor and the depressed state. Previous studies show how the vigor factor tends to reach its maximum value at times when maximum performance is required, such as near a competition for an athlete (Hernandez, Torres-Luque & Olmedilla, 2009; Huttunen, Kokko & Ylijokuri, 2004). However, the data obtained in the present study do not show a significant relationship ($p > 0.05$) between the vigor factor and the maximum expression of strength, expressed in terms of total load and subjective perception of effort in the maximum repetition. At the same time, the depressed state, a factor opposed to vigor, did not show a negative correlation with these variables. It is logical to expect an increase or decrease in these factors when their relationship has already been demonstrated in previous studies with athletes. Perhaps the sample size was too small to appreciate a significant relationship, or this relationship is only noticeable over an extended training period and not in a single session.

Regarding neuromuscular control, analyzed through the FTT, we looked for possible differences between the beginning and end of the protocol. The data obtained show that there is a significant difference in the second and third phases of the FTT (normal rhythm and slow rhythm) when evaluated after performing the warm-up and once the maximum bench press repetition is performed ($p < 0.05$). At the same time, we observed differences between series 1 and the maximum series, specifically in the first phase of the FTT (normal rhythm). These data corroborate those obtained in previous studies (Hernández, Morales & García, 2011). This fact may be due to a decrease or loss of motor control in the individual due to accumulated muscle fatigue, which translates into central nervous system saturation caused by a progressive increase in the recruitment of muscle fibers (Merletti, Rainoldi & Farina, 2001).

Regarding the expression of maximum strength, we evaluated four variables in the maximum series of the incremental test: Total load in the bench press, average propulsive velocity, subjective perception of effort, and force exerted with the manual dynamometer. Significant relationships have been found between the total load and average propulsive velocity and body weight. Our results are in line with what has been described in the specific literature, as studies related to this field, such as González-Badillo & Sánchez-Medina (2010), have reflected this earlier in the present decade. In addition, we can observe a positive correlation between the total load in the bench press and the force exerted with the manual dynamometer. This could be

due to what was explained by different authors (Sañudo, Fera, Carrasco, de Hoyo, Santos & Gamboa, 2012; Suchomel, Nimphius, Bellon & Stone, 2018), who explained that optimal strength expression was directly related to an increase in motoneuron recruitment.

Finally, there is a positive correlation between fatigue as a mood state and the total load, with this factor being evaluated at the beginning of the protocol before warming up, so it has not been affected by the course of the bench press test. One possible explanation is precisely that the mood state was evaluated right at the beginning of the protocol, so as the series progressed, the subjects mobilized a greater total load, with warm-up serving as an adaptation phase to the effort and fatigue as a mood state being a punctual manifestation in time.

Conclusion

In conclusion, according to our results, this study indicates that a higher level of physical activity is related to better mood and vigor in individuals.

As we have observed, there is a positive correlation between the total load in the bench press and the force exerted by the manual dynamometer in the maximum series. This suggests that the dynamometer, and therefore manual grip strength, could serve as a control element for future coaches to determine how well an individual is prepared to lift a load.

Finally, we have observed a relationship between neuromuscular control and the expression of strength, expressed in the different phases of the FTT evaluated at the beginning and end of the protocol. This translates into a decrease in neuromuscular control as we increase the load, due to a greater recruitment of motoneurons. This could be used to estimate load phases during strength training in relation to neuromuscular fatigue, allowing for individually tailored rest periods between sets.

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