Physiological Profile and Health Level of Athletes Engaged in Tug of War

Perfil fisiológico y nivel de salud de los atletas que participan en el tira y afloja

Authors

Natalia Tarabrina

Abstract

Background: The aim of the study was to compare the physiological profile and health level of tug of war (TW) athletes with those who do not engage in sports.
Methods: Thirty young men of 19.09±0.31 19.12±0.78 years involved in TW with Master of Sports qualification (athletes) and thirty young men of 19.35±0.2 years who do not engage in sports were analyzed for anthropometric parameters, aerobic power, isometric and dynamic strength, explosive power, flexibility, hematological profile and white blood cell count. The general health level was assessed using Apanasenko's express method.
Results: The body mass index of athletes was 14.52% lower ($p<0.05$), aerobic power was 42.8% ($p<0.01$) higher, isometric grip strength (dominant hand) and back strength was 35.38% and 33.53% ($p<0.05$) higher, and dynamic arm and leg strength was 16.66% and 23.09% ($p<0.05$) higher than in non-athletes. Flexibility and explosive power did not differ significantly. Hematological parameters were within the normal range, but erythrocytes, mean corpuscular hemoglobin concentration (MCHC) and hematocrit (HCT) were higher in athletes than in non-athletes ($p<0.05$). The leukocyte formula of blood revealed activation of non-specific reactions of the athletes' body, expressed in a decrease in the concentration of leukocytes and neutrophils, against the background of a significant increase in lymphocytes ($p<0.05$). The leukocyte formula of the blood revealed activation of non-specific adaptive reactions in the athletes' body, expressed as an increase in the lymphocyte-to-neutrophil ratio (LYM/NEUT, $p = 0.033$) as well as a change in the MID parameter (absolute number of a mixture of monocytes, eosinophils, basophils and immature cells) ($p = 0.032$). The athletes' health level corresponded to level IV (above average), while that of non-athletes corresponded to level I (low).
Conclusions: TW classes affect the level of health, increase strength and aerobic capacity, Long-term TW training is associated with a higher health level, greater strength and aerobic capacity, but do not significantly affect the development of flexibility and peak power. The data obtained can be used as model characteristics and for monitoring the physical fitness of students doing TW.

Keywords

Health level; Physiological profile; Tug of war

Resumen

Antecedentes: El objetivo del estudio fue comparar el perfil fisiológico y el nivel de salud de los atletas de tira y afloja (TA) con aquellos que no practican deporte.
Métodos: Se analizaron los parámetros antropométricos, potencia aeróbica, fuerza isométrica y dinámica, potencia explosiva, flexibilidad, perfil hematológico y recuento leucocitario de treinta hombres jóvenes de 19,09 ± 0,31 19.12±0.78 años que practicaban TA y con titulación de Máster en Deportes (atletas) y treinta hombres jóvenes de 19.35 ± 0.2 años que no practicaban deporte. El nivel de salud general se evaluó mediante el método exprés de Apanasenko.
Resultados: El índice de masa corporal de los atletas fue 14.52% menor ($p<0.05$), la potencia aeróbica fue 42.8% ($p<0.01$) mayor, la fuerza de agarre isométrico y de espalda fue 34.59% y 33.53% ($p<0.05$) mayor, y la fuerza dinámica de brazos y piernas fue 16.66% y 23.09% ($p<0.05$) mayor que en los no atletas. La flexibilidad y la potencia explosiva no difirieron significativamente. Los parámetros hematológicos estaban dentro del rango normal, pero los eritrocitos, la concentración de hemoglobina corpuscular media y el hematocrito fueron mayores en los atletas que en los no atletas ($p<0.05$). La fórmula leucocitaria de la sangre reveló la activación de reacciones no específicas del cuerpo de los atletas, expresadas en una disminución en la concentración de leucocitos y neutrófilos, en el contexto de un aumento significativo de linfocitos ($p<0.05$). La fórmula leucocitaria de la sangre reveló la activación de reacciones adaptativas no específicas en el cuerpo de los atletas, expresadas como un aumento en la relación linfocitos/neutrófilos (LYM/NEUT, $p = 0.033$) así como un cambio en el parámetro MID ($p = 0.032$). El nivel de salud de los atletas se situó en el nivel IV (superior a la media), mientras que el de los no atletas se situó en el nivel II (bajo).

Conclusiones: Las clases de TA influyen en el nivel de salud, aumentan la fuerza y la capacidad aeróbica, El entrenamiento a largo plazo con TW se asocia con un mayor nivel de salud, mayor fuerza y capacidad aeróbica, pero no afectan significativamente el desarrollo de la flexibilidad ni la potencia máxima. Los datos obtenidos pueden utilizarse como características del modelo y para el seguimiento de la condición física de los estudiantes que realizan TA.

Palabras clave

Nivel de salud; Perfil fisiológico; Tira y afloja.

Introduction

The tug of war (TW) is a team strength sport in which two teams use physical exertion and team tactics to move each other to the winning point while holding a rope (TWIF, 2026). TW is a very ancient pastime. TW competitions originate from ancient rituals and ceremonies. Evidence has been found in various parts of the world from Egypt and India to Myanmar and New Guinea. The origin of this game is unknown, but its history can be traced back to the Spring and Autumn period, i.e. more than 2500 years BC. TW is an ancient competition known in Egypt, India, China and New Guinea (for example, a XII century bas-relief at Konark Temple) (TWIF, 2026). In China, the game existed more than 2,500 years ago. Between In 1900 and 1920, TW was a part of the Olympic Games as a part of track and field (James, 2025; TWIF, 2026).

The first TW association was created in Great Britain in 1958, and in the early 1960s, the TW International Federation (TWIF) was founded (TWIF, 2026). Currently, as of January 2026, TWIF includes 76 national federations, TW is a part of the World Games. World championships are held annually among national teams: separately outdoors and indoors. Competitions are also held among clubs.

Thus, this sport is extremely popular all over the world, especially among student youth. To achieve sporting success, an athlete must have a high level of endurance and strength, as well as good coordination, a sense of rhythm and timing and psychological stability (Warrington et al., 2001). Therefore, training in this sport is very diverse and is a combination of strength exercises, cross training, endurance exercises and development of reaction speed with tactical and psychological training (Cayero, 2021).

This comprehensive training creates a unique physiological profile for the athlete (Castañeda-Babarro et al., 2022). This profile fundamentally distinguishes ropers from those competing in cyclic or speed-strength disciplines, rendering any extrapolation of data from other sports invalid.

An analysis of the available literature reveals an extremely limited number of studies devoted to the physiological and metabolic characteristics of athletes involved in TW. In particular, the issue of quantitatively assessing the differences between the physiological profiles of rope athletes and untrained individuals has been insufficiently addressed (Lin et al., 2016). Furthermore, meta-analyses that allow for an objective assessment of the impact of TW training on overall health, especially in the student population, are virtually nonexistent. Moreover, the importance of studying the physiological profile for key participants in athletic performance remains understudied and methodologically underdeveloped (Yu, 2025).

For coaches, the lack of clear physiological criteria leads to a system for selecting and designing training programs based primarily on empirical experience and external anthropometric indicators (James, 2025). The body's internal reserves, type of energy supply, recovery rate, aerobic and anaerobic metabolic thresholds, remain neglected (Yu, 2025). For sports physicians and medical-biological support specialists, this problem translates into a lack of reference values: it remains unclear which homeostasis shifts are a marker of overtraining, and which are physiological adaptations to exercise (Li et al., 2007). Finally, TW remains a ¨blind spot¨ for scientific researchers: the number of studies devoted to the metabolic reactions, biomechanics of tug-of-war, and the long-term health effects of such training is incomparably limited significantly inferior to sports compared to sports with similar popularity.

The relevance of this study is dictated by several factors. First, the high rate of injuries to the lumbar spine and arms (Huang et al., 2024) necessitates the development of preventive programs, which are impossible without an understanding of the physiological limiting factors. Secondly, the growing popularity of rope training among university students raises the question of the ¨cost of adaptation¨, that is, the alignment of the training process with the health-improving goals of physical education (Nasrulloh et al., 2024; Bahar, 2025). Thirdly, the lack of systematic data on the physiological profile of rope athletes hinders the implementation of modern biofeedback technologies and personalized training in this sport, which have long been standard in Olympic disciplines.

Therefore, a comprehensive study of the functional reserves, anthropometric characteristics and physical health of athletes specializing in rope training is not simply a scientific task, but a pressing practical need.

Method

Participants

The study involved thirty young men of 19.09±0.3 years (height 179.00±1.42 cm; body weight 79.99±1.51 kg), involved in TW, with 8.5±0.5 years of sports experience and qualification Master of Sports (athletes), and thirty young men of 19.35±0.28 years (height 175.25±1.15 cm; body weight 87.63±1.55 kg) not involved in sports (non-athletes).

All participants signed informed consent to participate in the studies, which were approved by the local ethics committee (Federal Scientific and Clinical Center of Sports Medicine and Rehabilitation of the Federal Medical and Biological Agency of Russia (Protocol No. 01-09, September 4, 2019)).

Procedure

The study was conducted over two days, with an interval of at least 48 hours but no more than one calendar day between tests to minimize variability in the subjects' physiological states. All tests within a single day were performed in a strictly defined sequence, taking into account the increasing intensity and specificity of fatigue. On the first day, venous blood was collected in the morning on an empty stomach for clinical analysis, followed by anthropometry and a battery of maximal strength tests: bench press, barbell squats, wrist and deadlift dynamometry. On the second day, subjects first performed a vertical jump to assess explosive strength, followed by a treadmill exercise test using the Bruce protocol to determine aerobic capacity. The study concluded with a flexibility assessment and a functional test involving 20 squats to calculate physical health indices using the Apanasenko method. All tests were conducted at the same time of day, from 8:00 AM to 11:00 AM.

Anthropometry

In the morning, on an empty stomach, body length and weight were measured. The height was measured using a stadiometer (model VMEN-200-50/100-D1-A, TVES, Russia). The body weight was measured using electronic digital scales (model VMEN-200-50/100-D1-A, TVES, Russia).

Aerobic Power

Aerobic power (VO_2submax) was assessed by the time of completing the stress test according to Bruce protocol on a treadmill (model Vision Fitness T-40, USA), and by the number of metabolic units METs (Benito-Peinado et al., 2005). Before the test, all subjects performed a standardized 5-minute warm-up of treadmill walking at 1.7 mph (2.7 km/h) with the incline set to zero. The speed of the incline of the treadmill was increased every 3 minutes. The test was stopped when the target heart rate of 150 beats/min was reached (submaximal level corresponding to 75% of the age-specific maximum heart rate for the examined group). Maximum oxygen uptake (VO_2MAX) was calculated using the formula (1): Therefore, the test was not maximal, and submaximal oxygen consumption (VO_2submax) or the estimated VO_2submax value was assessed. VO_2submax (peak oxygen consumption) indicator was calculated using formula (1):

$$VO_2\text{submax}=\text{METs}\times3.5, \tag{1}$$

where VO_2submax is the maximum amount of oxygen estimated submaximal oxygen consumption (ml/kg/min); METs is the unit of measurement of energy used by the body during physical activity (kcal).

METs was calculated using the formula (2) (Gibbons et al., 1997):

$$\text{METs}=(14.8-(1.379\times t)+(0.451\times t^2)-(0.012\times t^3))/35, \tag{2}$$

where t is the execution time rounded to tenths (min).

Strength and Power

Isometric strength of the hand and back muscles was measured using a dynamometers (models DRP-90 and DRP-200, NTMIZ, Nizhny Tagil, Russia). The subjects performed three exercises, resting for at least 30 sec between each attempt, the best result was taken into account for the assessment. The best value of three attempts was taken into account to evaluate the results. The subjects performed the test with their dominant and non-dominant hands (Buckinx & Aubertin-Leheudre, 2021).

Isometric strength of the back was measured using a back and leg deadlift dynamometer (DS-200, NTMIZ, Nizhny Tagil, Russia). The subject stood on a footrest with a dynamometer and, holding the handle with both hands, pulled it towards himself and up as hard as possible, straightening his knees. The measurements were repeated twice with a rest interval of 1 minute and the best result was recorded (Buckinx & Aubertin-Leheudre, 2021).

Upper and lower body strength was determined using bench presses and squats with a barbell to a position in which the knees were bent at an angle of 90° and the thighs were parallel to the floor. Maximal dynamic muscle strength of the upper and lower body was determined using bench presses and squats with a barbell to a position where the knees were bent at an angle of 90° and the thighs were parallel to the floor. After a standard warm-up consisting of 10 repetitions with a weight of about 60% of the estimated maximum, each subject attempted to lift successively heavier weights. The maximum weight with which the subject could perform one repetition with correct technique (one-repetition maximum) was assessed. The test ended when the subject failed to perform with the next weight (Buckinx & Aubertin-Leheudre, 2021). At least 3 minutes of rest were given between each trial.

Power (explosive strength) was determined by a standing two-legged jump. The test was performed in a special jumping sector. The subject assumed the starting position: feet shoulder-width apart, feet parallel and toes in front of the take-off line. Then, with a simultaneous push of both legs, he jumped upward as high as possible, touching the wall with his hand. Swinging of the arms was allowed (Buckinx & Aubertin-Leheudre, 2021).

The measurement was made using a measuring ruler along a vertical line (MYname, Ryazan, Russia). The participant performed three attempts with a rest interval of at least 2-3 minutes, and the best result was taken into account. The data were converted from centimeters to watts using the regression equation (3) published by (Sayers et al., 1999):

$$\text{Peak Power (W)} = 60.7 \times (\text{jump height [cm]}) + 45.3 \times (\text{body mass [kg]}) - 2055. \quad (3)$$

Flexibility

Flexibility was assessed using the Sit and Reach test (Baltaci et al., 2003). Before the test, each subject performed a standard warm-up consisting of a five-minute run on a treadmill at a speed of 10 km/h. An assistant attached a ruler to the edge of the mat so that the front edge of the mat coincided with the 15 cm mark on the ruler, and the zero end of the ruler was directed towards the subject. The ruler was positioned on the floor so that the zero mark was level with the subject's heels. A vertical bar was placed at the zero mark to stabilize the feet.

The subject sat on the floor with his legs fully straightened and slowly stretched along the top of the ruler as far as possible, holding the stretch for two seconds. The result of touching the toes (cm) was recorded. The test was performed three times. The average value of three attempts was taken into account. The distance from the zero mark (heels) to the fingertips was recorded in centimeters (a positive value indicates the subject reached beyond the heels). The test was performed three times, and the average of the three attempts was used.

Clinical Blood Test

To assess the morphological composition of the blood and the level of non-specific adaptive reactions of the body (NARB), all subjects underwent a comprehensive clinical analysis of peripheral blood. Blood sampling was standardized and was performed in the morning on an empty stomach from the cubital vein in the clinical diagnostic laboratory "Bionlab", Moscow, Russia. Some indicators of the leukocyte formula (LYM (%), NEUT (%), IMM (%), MON (%), EO (%), BA (%)) and morphological indicators of red blood (RBC (1012/L), HGB (g/L), MCHC (g/L), MCH (pg), MCV (fl), HCT (%), PLT, ((109/l)), as well as the erythrocyte sedimentation rate (ESR (mm/h)) were selected for observation.

Physical Health Level

The health level was assessed using the express method of Apanasenko (Apanasenko, 2004), including the following anthropometric and functional indicators

Based on the data recorded during the first visit, the height-weight index (Quetelet index) was calculated using the formula (4):

$$\text{Quetelet index} = \text{body weight} / \text{height (g/cm)}. \quad (4)$$

Vital capacity (VC) was measured using a Spirolab I spirometer (MIR Medical International Research, Italy) (Kameneva et al., 2023). The subject stood, took a deep breath as deeply as possible, then exhaled as fully and smoothly as possible into the spirometer mouthpiece. A nose clip was placed over the nose during exhalation. Three attempts were made, 30-60 seconds apart, and the best result was recorded. The VC vital index was calculated as the ratio of VC (ml) to body weight (kg).

Systolic blood pressure (BP) and heart rate (HR) were measured with an automatic tonometer (Omron M3, Japan) on the left arm in a sitting position after a 5-minute rest (Karpman et al., 1988). Measurements were taken twice at a 2-minute interval, and the mean value was used for analysis. The Robinson Index (RI) was calculated using the formula (Karpman et al., 1988):

The Robinson index (RI) was calculated using the formula (5):

$$RI = HR \times SB / 100, \text{ relative units,} \quad (5)$$

where HR is the heart rate, SB is the systolic blood pressure,

The strength index (SI) was calculated using the formula (6):

$$SI = \text{hand strength} / \text{body weight}, \%. \quad (6)$$

Heart rate recovery after a standard exercise was assessed using the Martine-Kushelevsky test (Karpman et al., 1988). The baseline heart rate was measured by palpation of the radial artery for 10 seconds (converted to minutes) in a standing position. The subject then performed 20 deep squats with arms extended forward for 30 seconds. Immediately after the exercise, the heart rate was measured again for 10 seconds, and the time it took for the heart rate to return to the baseline was measured (with checks every 30 seconds). Recovery time was recorded in minutes.

The overall health level was assessed in points. Each parameter under study was assigned a corresponding number of points, according functional levels: 1 – low level, 2 – below average level, 3 – average level, 4 – above average level, 5 – high level of health (Apanasenko, 2004).

Statistical Analysis

Statistical analysis was performed using Microsoft Excel and STATISTICA – 10.0. Normality of distribution was tested using the Shapiro-Wilk criterion. All analyzed variables were confirmed to conform to the normal distribution law ($p > 0.05$), which led to the use of parametric comparison methods. Equality of variances within groups was assessed using Levene's test (Montero, 2026). Student's t-test for independent samples (unpaired t-test) was used to compare the two groups (athletes vs. non-athletes) for paired comparison of groups. The arithmetic mean (M) was used as a measure of central tendency, and the standard error of the arithmetic mean (m) was used as a measure of dispersion.

Results

The Table 1 shows that the average age of the athletes was 19.12±0.78 years old, while that of the non-athletes was 19.35±1.2 years old ($p>0.05$), indicating that the groups were comparable. The athletes were taller, with the height of 179.00±2.43 cm versus 175.25±2.84 cm for non-athletes, but they had lower body weight: 79.99±1.51 kg versus 87.63±1.55 kg for non-athletes, respectively ($p<0.001$). Analyzing the data obtained during the stress test, it was determined that the athletes' time to complete the test before reaching submaximal HR was 13.12±0.2 min, which corresponded to 13.6±0.2 METs, and VO_2submax level was 47.56±1.3 ml/kg/min. In the group of non-athletes, the stress test time was 8.32±0.3 min, which was 7.77±0.2 METs, and VO_2submax level was 27.2±0.3 ml/kg/min.

Table 1. Anthropometric and functional parameters of TW athletes and non-athletes

Indicators (units)	Athletes	Non-athletes	Percentage difference (%)	Normative values
Age (years)	19.12±0.78	19.35±1.20	1.20	N/A
Height (cm)	179.00±2.43	175.25±2.84	2.09	N/A
Body weight (kg)	79.99±1.51	87.63±1.55	9.55	N/A
Body mass index (kg/m^2)	24.99±1.2	28.63±1.4	14.56	N/A
VO_2submax (ml/kg/min)	47.56±1.3	27.2±0.3	42.80♦♦	37–44
F dominant hand (kg)	62.25±8.2	40.22±5.2	35.38♦	54–68
F non-dominant hand (kg)	58.10±5.0	38.50±4.0	33.8♦	54–68
F back (kg)	165.50±8.0	110.0±9.0	33.53♦	140–160
F arms (kg)	60.00±4.0	50.00±4.0	16.66♦	70–110
F legs (kg)	162.53±2.5	125.00±3.0	23.09♦	160–230
Peak power (W)	4659.8±150.2	3624.5±130.0	22.21	4957–5995
Flexibility (cm)	19.4±1.9	25.3±2.0	23.32	15–30

Note: Significant difference between the groups, ♦ is the p<0.05, ♦♦ is the p<0.01, (unpaired t-test). N/A, Not available. Normative values for VO_2submax, hand grip strength, back strength, arm strength, leg strength and peak power are taken from (Warrington et al., 2001).

The strength of the dominant hand in athletes is 62.25±8.2 kg, in non-athletes it is 40.22±5.2 kg, and in non-dominant it is 58.10±5.0 kg and 38.50±4.0 kg, respectively. The deadlift strength of the back muscles in the athletes' group was 165.50±8.0 kg, while in the non-athletes' group it was 110.0±9.0 kg. A comprehensive assessment of the strength of the upper and lower body parts, determined during the bench press and squat tests, showed that the arm muscle strength of athletes was 60.00±4.0 kg, while that of non-athletes was 50.00±4.0 kg; leg strength was 162.53±2.5 kg and 125.00±3.0 kg, respectively. Peak (explosive) power in athletes was amounted to 4659.8±150.2 W and for non-athlets it was 3624.5±130.0 W, respectively. Flexibility indices in the Sit and Reach test did not differ significantly between the groups (Table 1).

The Table 2 shows hematological indices of red blood and ESR and the Table 3 shows the composition of the leukocyte formula and the index of non-specific adaptation reactions in TW athletes and non-athletes.

Table 2. Comparison of red blood morphological parameters in TW athletes and non-athletes

Blood parameters (units)	Athletes	Non-athletes	Difference, %	P
RBC (10^12/l)	4.99±0.08	4.51± 0.12	-9.61	0.003711**
HGB (g/l)	142.18±3.39	138.35±3.35	-2.69	0.437192
MCHC (g/l)	334.49±16.80	312.30±42.51	-6.63	0.015152*
MCH (pg)	29.88±0.21	28.67±0.46	-4.04	0.082512
MCV (fl)	87.32±1.20	85.92±1.80	-1.60	0.549305
HCT (%)	53.45±2.25	41.29±2.68	-22.75	0.040861*
PLT (10^9/l)	222.81±9.50	221.28±9.60	-0.68	0.912378
ESR (mm/h)	8.14±1.07	5.78±1.41	-28.99	0.196731

Note: RBC is the red blood cells; HGB is the hemoglobin; MCHC is the corpuscular hemoglobin concentration; MCH is the corpuscular hemoglobin content; MCV is the corpuscular volume; HCT is the hematocrit; PLT are the platelets; ESR is the erythrocyte sedimentation rate; p is the significance of differences in parameters relative to baseline; * is the p<0.05; ** is the p<0.01; *** is the p<0.001, Student's t-test.

The Table 2 shows that Statistically significant differences were found between the groups for the following parameters: the red blood cell count (RBC) was 4.99±0.08 10^{12}/l in athletes and 4.51±0.12 10^{12}/l in non-athletes (p=0.0037); the mean corpuscular hemoglobin concentration (MCHC) was 334.49±16.80 g/l and 312.30±42.51 g/l, respectively (p=0.015); hematocrit (HCT) was 53.45±2.25% in athletes versus 41.29±2.68% in non-athletes (p=0.041). No significant differences were found for other parameters (HGB, MCH, MCV, PLT, ESR).

Table 3. Comparison of morphological parameters of white blood, leukocyte formula and NARB in athletes engaged in TW and non-athletes

Blood parameters (units)	Athletes	Non-athletes	Difference, %	P
WBC (10^9/l)	5.76±0.27	6.08±0.40	5.55	0.509870
LYM (10^9/l)	2.16± 0.18	2.20±0.15	-1.8	0.514000

MID (10^9/l)	0.49± 0.04	0.66± 0.06	34.69	0.031975*
GRa (10^9/l)	3.06±0.26	3.15±0.25	2.94	0.694886
EOS (%)	2.33±0.47	1.50±0.25	-35.62	0.164775
Band neutrophils (%)	2.83±1.17	1.50±0.84	-46.99	0.000004***
Segmented (%)	42.67±7.39	57.50±8.43	34.75	0.054318*
LYM (%)	37.50±8.57	34.00±8.58	-9.33	0.079150
MON (%)	5.00±2.07	4.83±2.74	-3.4	0.896087
LYM/NEUT	0.74±0.06	0.55±0.05	-25.67	0.033048*

Note: WBC are the leukocytes; LYM is the absolute lymphocyte count; MID is the absolute number of a mixture of monocytes, eosinophils, basophils and immature cells; GRa is the absolute granulocyte count; EOS are the eosinophils; MON are the monocytes; LYM /NEUT is the ratio of lymphocytes and segmented neutrophils; * is the p<0.05; *** is the p<0.01, reliability of differences in indicators relative to the baseline, Student's t-test.

Analysis of the leukocyte formula showed that statistically significant differences were found between the groups for the following parameters: the absolute lymphocyte count (LYM) was 5.47±0.18 10^9/L in athletes and 2.20±0.15 10^9/L in non-athletes (p<0.001); MID was 0.49±0.04 10^9/L and 0.66±0.06 10^9/L, respectively (p=0.032); the lymphocyte to neutrophil ratio (LYM/NEUT) was 0.74±0.06% in athletes versus 0.55±0.05% in non-athletes (p=0.033). No significant differences were found for the remaining parameters of the leukocyte count (Table 3) MID was 0.49±0.04×10^9/L in athletes and 0.66±0.06×10^9/L in non-athletes (p=0.032); the lymphocyte to neutrophil ratio (LYM/NEUT) was 0.74±0.06 in athletes versus 0.55±0.05 in non-athletes (p=0.033). No significant differences were found in other leukocyte parameters, including WBC, absolute and relative lymphocyte count (LYM, LYM%), GRa, EOS%, band and segmented neutrophils (p=0.054) and MON% (Table 3).

Table 4. Comparative analysis of the physical health of athletes engaged in TW and non-athletes with the criteria of rapid assessment of the level of physical health according to Apanasenko

Indicators	Low level	Below average level	Average level	Above average level	High level	Athletes	Non-athletes
Quetelet index, g/cm	>501 (-2)	451-500 (-1)	<450 (0)	-(-)	-(-)	446.42±25.0	500.74±55.9
Vital index, ml/kg	<50 (-1)	51-55 (0)	56-60 (1)	61-65 (2)	>66 (3)	61.28±1.20	43.93±1.30***
Strength index, %	<60 (-1)	61-65 (0)	66-70 (1)	71-80 (2)	>80 (3)	75.22±2.87	66.88±2.27***
Robinson index, conventional units	>111 (-2)	95-110 (-1)	85-94 (0)	70-84 (3)	<69 (5)	54.78±0.86	86.25±2.26*
HR recovery time after 20 squats in 30 sec, min	>3 (-2)	2-3 (1)	1.5-2.0 (3)	1.0-1.5 (5)	<1 (7)	1.40±0.02	2.0±0.03*
Overall rating, points	<3	4-6	7-11	12-15	16-18	14	2

Note: Significant difference between the groups, * is the p<0.05, ** is the p<0.01, *** is the p<0.001 (unpaired t-test).

As a result of the study of the level of physical health, it was revealed that the body mass index Quetelet index of athletes was 446.42±25.0 g/cm, and in non-athletes it was 500.74±55.9 g/cm, the VC of athletes was 4901.76±864.94 ml, and in non-athletes it was 3850±598.28 ml. The vital index of athletes was equal to 61.28±1.20 ml/kg, against 43.93±1.30 ml/kg in non-athletes. The strength index of the rope climbers and non-athletes was 75.22 and 66.88%, respectively. Considering the systolic function of the heart by RI (double product), it was determined that in the group of athletes this parameter corresponded to 54.78±0.86 conventional units, and in non-athletes 86.25±2.26 conventional units. The pulse recovery time after 20 squats in athletes was 2.0±0.03 and in non-athletes was 1.40±0.02, respectively. In rope climbers, the total express assessment was equal to 14 points, in non-athletes it was equal to 2 points.

Discussion

The results of this study describe the impact of TW training on the physiological parameters of athletes, as well as on their level of physical health. For comparison purposes, data from students not involved in sports were analyzed. The results of this cross-sectional study describe differences in physiological parameters between TW athletes and non-athlete students, as well as differences in their physical health levels.

We found that with greater height and lower body weight, the Quetelet index in athletes engaged in TW was 14.52% lower ($p<0.05$), and the level of aerobic power was 42.8% higher than in non-athletes and significantly exceeded not only the population standards (31–42 ml/kg/min), but also the model values for athletes training for endurance.

This result seems unexpected, as TW is traditionally considered a speed-strength sport with a predominantly anaerobic energy supply. However, the observed high VO_2submax may indicate a pronounced cross-adaptation effect due to the specific nature of the training process in TW (Warrington et al., 2001) However, the observed high VO_2submax may be related to the specificity of the training process in TW (Warrington et al., 2001) and the possible effect of cross-adaptation.

A likely explanation is that competitive A tentative explanation is that the structure of competitive activity in TW (especially during prolonged bouts) places increased demands on the oxygen transport system and the body's ability to resynthesize ATP through oxidative processes between maximal efforts (Cayero et al., 2021). Furthermore, high VO_2submax may be a consequence of long-term cardiovascular adaptation to regular intense exercise (Castañeda-Babarro et al., 2022), which is consistent with the characteristics of the red blood cells we found in athletes: they had a significantly higher RBC count (RBC: +9.61%, $p=0.0037$), HCT (HCT: +22.75%, $p=0.041$), and MCHC (MCHC: +6.63%, $p=0.015$) compared to non-athletes, which provides increased oxygen-carrying capacity of the blood. In a study (Warrington et al., 2001), a direct correlation between lean body mass and all three hematological parameters was demonstrated using regression analysis. Furthermore, the observed association between elevated RBC, HCT and MCHC with high VO_2submax in rope athletes is consistent with data from a study conducted among athletes in Port Harcourt, whose authors found a positive correlation between VO_2submax and hematocrit, RBC and hemoglobin levels (Gwotmut, 2023).

Considering the leukocyte count of the athletes' blood, we can observe a decrease in the concentration of leukocytes and neutrophils, accompanied by a reliable increase in the level of lymphocytes. At the same time, according to the classification of (Garkavi et al., 1990), such changes in the white blood cell count correspond to the response of increased activation: the LYM is more than 33%, the monocytes are 2-8%, and the segmented neutrophils are 44-49%, with the normal range for leukocyte concentrations from 4.0 to 7.0×109/l (Garkavi et al., 1990).

The results obtained are fully consistent with this classification and reflect the athletes' physiological adaptation to exercise, which can be considered precisely as a response of increased activation. Within this response, a significant increase in lymphocytes (lymphocytosis) indicates immune mobilization, necessary for the repair of microtrauma in muscle tissue. A decrease in MID (likely due to monocyte migration into tissue) combined with a high LYM/NEUT index indicates a redistribution of resources: the body does not respond to external threats, but focuses on internal homeostasis and regeneration. A high LYM/NEUT index also confirms the absence of acute stress, since, unlike the inflammatory pattern (increased neutrophil count), athletes' neutrophils are not hyperactivated, indicating successful stress management without disruption of adaptation (Li et al., 2007).

An examination of the leukocyte profile of the athletes' blood revealed statistically significant differences between the groups for only two parameters: MID (mixture of monocytes, eosinophils, basophils and immature cells) and the lymphocyte-to-neutrophil ratio (LYM/NEUT). No significant differences were found for the remaining leukocyte parameters. According to the classification (Garkavi et al., 1990), the range of lymphocytes >33%, monocytes 2–8%, segmented neutrophils 44–49% with a leukocyte norm of 4.0–7.0×10^9/L corresponds to a reaction of increased activation. In athletes, the relative content of lymphocytes and monocytes, as well as the total number of leukocytes, fully meet these criteria. However, the proportion of segmented neutrophils in athletes was below the lower limit of the specified range. Thus, the observed leukogram pattern is generally similar to a response of increased activation, but with incomplete correspondence in the neutrophil component. A decrease in MID (likely due to the migration of monocytes and eosinophils into the tissue) combined with an increased LYM/NEUT ratio suggests a redistribution of cellular resources without signs of acute inflammatory stress. This is consistent with the concept of successful physiological adaptation of the body to regular physical activity (Li et al., 2007).

Along with the identified characteristics of the white blood cell count, reflecting the state of nonspecific adaptation in athletes, the most important component determining the success of competitive activity in the training camp is the level of strength development.

Strength is one of the most important factors influencing athletic performance in TW (Warrington et al., 2001). To ensure a high level of resistance, athletes need well-developed muscles of the back, legs and upper shoulder girdle. The muscles of rope athletes work mainly in an isometric mode, alternating with slow concentric and eccentric contractions with strong resistance (Warrington et al., 2001). The combination of eccentric and concentric muscle contractions, as they believe, gives the best result in strength training, as it increases muscle strength and mass. The importance of isometric strength is confirmed by the high level of grip strength (hand strength) and back strength recorded in the group of athletes. Thus, hand strength is 35% higher than in untrained subjects, and back strength is 33%. Interestingly, the back strength of ropers significantly exceeded the average values for age-appropriate normative data (140–160 N) (Warrington et al., 2001) and was higher than that of highly qualified yachtsmen (Bojsen-Møller et al., 2015). Our data are consistent with the results obtained in rowers (Volianitis et al., 2020), rugby players (Tarabrina & Wilczewski, 2022).

To assess the dynamic strength of the upper and lower body, bench press and squats with a barbell were used. An analysis of bench press data revealed that the absolute arm strength values of rope lifters (60.00±4.0 kg) are below the standards typical for representatives of classical strength disciplines (70–110 kg), but exceed those of untrained individuals by 16.66%. Meanwhile, the leg strength of rope lifters (162.53±2.5 kg) practically reaches the lower limit of model values for strength sports (160–230 kg) and is 23.09% higher than that of non-athletes. The obtained results, perhaps, can be explained by the non-specific nature of the test for this sport, where the main emphasis is on the pulling action involving the latissimus dorsi, biceps, brachialis and rhomboid muscles. In the bench press, on the contrary, the movements are pushing, involving the pectoralis major, deltoid muscles and triceps (Warrington et al., 2001). The dynamic strength of the legs was significantly higher in the group of athletes, compared to untrained subjects. It should also be noted that TW is a sport where the athlete's weight is important, therefore, in further studies it is advisable to calculate the strength values relative to body weight.

Analyzing the peak explosive power, it was determined that in athletes it is 22% higher than in untrained subjects, but lower than the model parameters of athletes (4957–5995 W). Moreover, according to the literature, they were lower than those of rugby players (Tarabrina & Wilczewski, 2022), yachtsmen (Volianitis et al., 2020) and taekwondo athletes (Bridge et al., 2014), which may be due to the lack of specificity of the test. The results of the flexibility test did not reveal a significant difference between athletes and non-athletes. Although the average flexibility values for both groups were within the expected range, they were lower in the athlete group than the values recorded in non-athletes. It can be assumed that such limitations are associated with overstrain of the hamstrings and lower back muscles. Despite the fact that the sit and reach test is widely used to determine general flexibility, the results obtained may be influenced by anthropometric factors such as limb length and torso size (Baltaci et al., 2003). However, the choice of this test may be justified by the fact that the kinematics of movements in TW and this test are similar.

Thus, the physiological and metabolic profile is the foundation of physical health. Express assessment by the method of Apanasenko allows to say that systematic TW classes influenced the level of physical health of students showed significant differences between groups: in the group of athletes, the functional level corresponded to the fourth health level on the Apanasenko scale (above average), and in students not involved in sports, the first level (low). According to (Apanasenko, 2004), “a safe level of health corresponds to the IV-V functional level”. Therefore, we can say that systematic TW training helps to raise the level of health to a safe level. The results of this cross-sectional study suggest that regular TW participation is associated with higher levels of physical health. Longitudinal studies are needed to establish causal relations.

Conclusions

We concluded that long-term TW training affects the physiological profile and increases strength and aerobic power, but does not significantly affect the development of flexibility and peak power We concluded that long-term TW training is associated with changes in the physiological profile of athletes: higher strength and aerobic power, while no significant effect on flexibility and peak power was found. Changes in some hematological parameters in the form of an increase in the concentration of hemoglobin and erythrocytes indicate adaptation to physical activity. A change in NARB towards activation is indicated by an increase in the lymphocyte to neutrophil ratio in the leukocyte formula of the blood. The overall express assessment of the athletes' health indicates a positive effect of TW training on the overall health level. The observed changes in a number of hematological parameters (increased red blood cell count and mean corpuscular hemoglobin) indicate adaptation to physical activity. A shift in nonspecific adaptive responses toward activation is confirmed by an increased lymphocyte-to-neutrophil ratio and a decrease in the MID (a mixture of monocytes, eosinophils, basophils and immature cells) level in the white blood cell count. Results of a rapid assessment of the athletes' physical health indicate that systematic TW training is associated with higher levels of overall health. However, due to the cross-sectional design and small sample size, longitudinal studies are required to definitively confirm these findings.

Practical Applications

The study's results expand existing understanding of the key physical qualities that determine success in TW and allow for the optimization of the training process. The data obtained will help coaches and athletes develop modern training programs aimed at improving competitive performance. The positive impact of TW training on health substantiates its use as an effective means of improving physical fitness.

Limitations

This study has several limitations, including a small sample size, cross-sectional design, and the specificity of the participant population (students from a single university). These limitations require caution in interpreting the results and necessitate their confirmation in larger, more methodologically rigorous studies. However, the findings are of undeniable scientific value, as TW is rarely the subject of biomedical research.

Future Lines of Research

Taking into account the identified limitations, a promising direction seems to be the organization of longitudinal observations of the dynamics of physiological indicators of ropers, expansion of the sample by involving athletes of different genders and qualification levels, as well as an in-depth study of the mechanisms of the identified hematological shifts and the development of training programs aimed at correcting flexibility and peak power.

Conflict of Interest Statement

The authors confirm that they have no conflicts of interest related to the conduct of the study and preparation of the publication. This work was not funded by any third-party organizations that could influence the presentation or interpretation of the data obtained.

References

Apanasenko, G. L. (2004). Diagnosis of individual health. *Hygiene and Sanitation*, 2, 55-58. (In Russ.)

Bahar, A. (2025). The effectiveness of traditional tug of war game in improving arm muscle strength of elementary school students at SD Telkom Makassar. *COMPETITOR: Journal Pendidikan Kepelatihan Olahraga*, *17*(3), 3376–3383.

Baltaci, G., Un, N., Tunay, V., Besler, A., & Gerçeker, S. E. L. D. A. (2003). Comparison of three different sit and reach tests for measurement of hamstring flexibility in female university students. *British Journal of Sports Medicine, 37*(1), 59-61.

Benito-Peinado, P. J., Calderón-Montero, F. J., García-Zapico, A., & Peinado-Lozano, A. B. (2005). Validity and reliability of an incremental ramp test for active persons. *International Journal of Sport Science*, 1(1), 46–63. https://doi.org/10.5232/ricyde2005.00104

Bojsen-Møller, J., Larsson, B., & Aagaard, P. (2015). Physical requirements in Olympic sailing. *European Journal of Sport Science, 15*(3), 220-227. https://doi.org/10.1080/17461391.2014.955130

Bridge, C. A., Ferreira da Silva Santos, J., Chaabene, H., Pieter, W., & Franchini, E. (2014). Physical and physiological profiles of taekwondo athletes. *Sports Medicine*, 44, 713-733. https://doi.org/10.1080/17461391.2014.955130

Buckinx, F., & Aubertin-Leheudre, M. (2021). Physical performance and muscle strength tests: pros and cons. In *Sarcopenia: Research and clinical implications* (pp. 65-99). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-80038-3_7

Castañeda-Babarro, A., Santamaría, B. G., Coca, A., Calleja-González, J., & Cayero, R. (2022). Assessment of Tug of War pullers competition intensity and physiological response at the 2019 European Championship. *Retos, 44,* 357–363. https://doi.org/10.47197/retos.v44i0.90398

Cayero, R., Rocandio, V., Zubillaga, A., Refoyo, I., Calleja-González, J., Castañeda-Babarro, A., & Martínez de Aldama, I. (2021). Analysis of tug of war competition: A narrative complete review. *International Journal of Environmental Research and Public Health*, *19*(1), 3. https://doi.org/10.3390/ijerph19010003

Garkavi, L.H., Kvakina, E.B., & Ukolova M.A. (1990). *Adaptive reactions and body resistance*. Rostov on Don: Publishing House of Rostov. University, 240 p. (In Russ.)

Gibbons, R. J., Balady, G. J., Beasley, J. W., FAAFP, Bricker, J. T., Duvernoy, W. F., ... & Yanowitz, F. G. (1997). ACC/AHA guidelines for exercise testing: executive summary: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee on Exercise Testing). *Circulation*, *96*(1), 345-354.

Gwotmut, M. D. (2023). Relationship between cardiorespiratory fitness, maximum oxygen consumption [Vo2max] and some hematological parameters in athletes in Port Harcourt. *Unizik Journal of Educational Research and Policy Studies*, *15*(2), 185–200.

Huang, C.-H., Liu, K.-C., Cheng, J.-W., Hsu, S.-C., & Chen, C.-K. (2024). Carpal Tunnel Syndrome in Elite Female Tug-of-War Athletes: Prevalence and Risk Factor Analysis. *Diagnostics*, *14*(19), 2120. https://doi.org/10.3390/diagnostics14192120

James, E. (2025). *Tug of war.* Oslo: Publifye AS.

Kameneva, M. Y., Cherniak, A. V., Aisanov, Z. R., Avdeev, S. N., Babak, S. L., Belevskiy, A. S., ... & Chushkin, M. I. (2023). Spirometry: national guidelines for the testing and interpretation of results interregional public organization «Russian respiratory society» All-Russian public organization «Russian Association of Specialists in functional diagnostics» All-Russian Public Organization «Russian Scientific Medical Society of Therapists». *Pulmonology*, *33*(3), 307–340. (In Russ.)

Karpman, V. L., Belotserkovsky, Z. B., & Gudkov, I. A. (1988). *Testing in sports medicine*. Moscow: Physical education and sports. (in Russ.)

Li, T. L., Lin, C. L., Hung, C. J., & Tseng, K. T. (2007). The Effect of Repeated Intensive Pulls of Tug-of-War on Immunoendocrine Responses. *Infection, 17*, 19.

Lin, Y. T., Kuo, C. H., & Chen, Y. C. (2016). Differences in force gradation between tug-of-war athletes and non-athletes during rhythmic force tracking at high exertion levels. *China Journal of Physiology*, *59*, 260-267.

Montero, J. A. (2026). A structured guide to univariate test selection based on normality, variance homogeneity, and graphical data exploration. *Journal of Surgical Research, 318*, 230–240.

Nasrulloh, A., Hermawan, H. A., & Ihsan, F. (2024). Health benefits of traditional games: a systematic review. *Retos, 59*, 843–856. https://doi.org/10.47197/retos.v59.107467

Sayers, S. P., Harackiewicz, D. V., Harman, E. A., Frykman, P. N., & Rosenstein, M. T. (1999). Cross-validation of three jump power equations. *Medicine and Science in Sports and Exercise*, *31*(4), 572-577. https://doi.org/10.1097/00005768-199904000-00013

Tarabrina, N. Y., & Wilczewski, T. (2022). Physiological characteristics of strength component of special endurance in rugby players. *Human. Sport. Medicine, 22*(2), 7-14. https://doi.org/10.14529/hsm220201

TWIF. (2026). *Tug of War International Federation*. https://tugofwar-twif.org/

Volianitis, S., Yoshiga, C. C., & Secher, N. H. (2020). The physiology of rowing with perspective on training and health. *European Journal of Applied Physiology*, *120,* 1943–1963. https://doi.org/10.1007/s00421-020-04429-y

Warrington, G., Ryan, C., Murray, F., Duffy, P., & Kirwan, J. P. (2001). Physiological and metabolic characteristics of elite tug of war athletes. *British Journal of Sports Medicine*, *35*(6), 396-401.

Yu, L. (2025). Focus on Exercise Physiology and Sports Performance. *Life*, *15*(1), 84. https://doi.org/10.3390/life15010084

Authors' and translators' details: