

Physical fitness assessment for lower limb disability: rationale and design to develop a new formula



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ABSTRACT

Introduction: Injuries are a major medical problem in military populations. The physical fitness assessment is a series of tests that measure and monitor physical fitness levels. The existing physical fitness assessment and formula used by the Indonesian Military requires a running test that only applies to healthy soldiers. This study attempted to construct a formula for assessing physical fitness using tests that soldiers may perform with lower limb injury/disability.

Method: The design of the study was an internal cross-sectional comparison. This study included 104 healthy, well-trained male normal soldiers (NS) and 50 injured or disabled soldiers (DS) who matched the inclusion criteria. The NS was required to perform a 12-minute running and wheeling test, a ball-throwing test, push-ups, and lunges. The DS was also required to perform the same tests except for the 12-minute running test and lunges. The analysis of the data consisted of four steps: constructing a conceptual framework, describing the characteristics of each group, identifying significant indicators using Partial Least Square-Structural Equation Modeling (PLS-SEM) to develop a physical fitness formula, and determining whether the formula is appropriate for assessing physical fitness in running and wheeling tests.

Result: There is no significant difference in the characteristics of NS and DS ($p > 0.05$); thus, the subjects in both groups are comparable. Physical fitness test has several major contributing factors: distance, test method, muscle strength, and age. There is no significant difference in the number of NS in each category between the running and wheeling tests ($p > 0.05$).

Conclusion: Physical fitness formula = $\{1.1 \times (0.98 \times \text{distance}) + (0.97 \times \text{method value}^{**})\} - (0.093 \times \text{age}) - (0.17 \times \text{muscle strength}^{***})$ Note: *) Distance traveled during running or wheeling test (meter). **) The running test method value is entered as 1, and the wheeling test method value is entered as 2. ***) The value of wheeling muscle strength is obtained from the ball-throwing test. In contrast, the value of running muscle strength can be determined by multiplying the result of the ball-throwing test by 2. These findings may be used for assessing the physical fitness of normal soldiers or those with lower limb injury/disability.

Keywords: Physical fitness formula, wheeling test, injury, disability.

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INTRODUCTION

Injuries are a major medical problem in military populations. In training and operational conditions, soldiers are exposed to intense physical demands,¹ which increases their risk of injuries. Indonesian Soldier's Disability Evaluation Committee data shows that about 10% of all injured soldiers will become disabled.² Indonesia's Ministry of Defence's Rehabilitation Center statistics showed that in 2018, approximately 75% of 6640 disabled soldiers aged 23 to 58 suffered from below the lumbar region injuries,

such as fracture, amputation of the hip and knee amputation, or ankle, and spinal cord injury.² Despite having a disability, a soldier may be in good health and able to contribute to the military. A proper physical fitness assessment may play a significant role in evaluating the improvement of physical fitness during the rehabilitation program, determining the optimal training intensity³ and readiness to return to duty.

The physical fitness assessment is a series of tests that measure and monitor physical fitness.⁴ Physical fitness is "the ability to carry out daily tasks with vigor

and alertness, without undue fatigue and with ample energy to enjoy leisure-time pursuits and to meet unforeseen emergencies". It comprises various elements that can be further categorized as health-related and skill-related components.⁵ The physical fitness assessment evaluates the five components of fitness that comprise overall fitness: cardiovascular endurance, muscular strength and endurance, flexibility and body composition.^{5,6} The existing physical fitness assessment and formula used by the Indonesian Military requires a running test that only applies to healthy soldiers.⁷

Most injured or disabled soldiers require a wheelchair for mobilization and exercising during their rehabilitation program. Hence, the wheeling test seems to be an appropriate substitution for the running test as a component of the physical fitness assessment for DS. It is also important to analyze different types of tests for DS and their relevance to physical fitness.

In order to find the right formula to assess the fitness score, it is important to know how the human body works holistically. The formula must include indicators already used by the military, which can also be used for people with disabilities. From the components involved in physical activity, assessable indicators must be identified to construct a model from which formula may be derived. Five categories are made based on the 20th, 40th, 60th, and 80th percentiles from the formulas applied to the normal subjects. The formula will be confirmed by comparing the number of subjects in each category of running and wheeling tests on normal subjects. This study attempted to construct a formula for assessing physical fitness using tests that soldiers may perform with lower limb injury/disability.

METHODS

The design of this study was an internal cross-sectional comparison between the injured or disabled soldiers (DS) and normal soldiers (NS) groups.

Subjects

Inclusion criteria for DS: Indonesia National Armed Force soldiers (TNI) aged between 19 to 58 years with mild leg problems which can use a wheelchair, do push-ups, and throw a ball with both hands but cannot run. The subject is healthy based on the latest medical check-ups. Vital signs, hemoglobin and blood glucose levels are within normal limits. Subjects had engaged in physical development activities adjusted to their regular routines at least four weeks before the test. Subjects agreed to take part in the research and signed the informed consent.

Inclusion criteria for NS: Active and healthy TNI soldiers, based on the latest medical check-up, perform work activities according to daily habits required by the

institution. Exclusion criteria: Subject diagnosed with metabolic, cardiovascular, respiratory, neuro-musculoskeletal, vision and balance disorders. Subject unable to follow orders properly. Drop-out criteria: The subject was injured, refused to continue, or the data was incomplete due to other factors.

Procedures

After the completion of informed consent, a medical examination was performed, including clinical examination, HR, blood pressure, temperature, hemoglobin, and random blood glucose. The subjects were fitted with a smartwatch equipped with Global Positioning System (GPS) on their hand to measure HR and distance.

The protocol for NS consisted of a 12-minute running and wheeling test, a ball-throwing test, push-ups, and lunges. The DS will perform the same protocols except for the 12-minute running test and lunges. The running and wheeling tests were performed on a 400-meter circular track. Each subject completed each test separated by at least 72 hours. The used wheelchair is a 26-inch-diameter sports wheelchair.

The ball throwing test was performed by throwing a 2 kg ball. The measured distance was attained when the ball initially made contact with the ground, regardless of how far it rolled. This test was performed while seated on a chair for both NS and DS. The seated position must be upright, with both feet on the ground. The warm-up was done by swinging both arms back and forth before throwing the ball as far as possible. The back of the chair was supported to prevent it from falling backward. Disabled soldiers with limited trunk strength was assisted with a cloth wrapped around the torso to aid in torso strength and balance.

The push-ups test performed was modified knee push-ups for both NS and DS. The subject was positioned in an all-fours position with knees flexed and touching the floor; the body formed a straight line from shoulders to knees. The arm is bending until the chest nearly touches the floor, then the body should be pushed back up. This movement was done repeatedly for one minute.

The NS only performed a lunges test.

Lunges were started in a straight-up position, shoulders relaxed, chin up, and arms at the side. With one leg forward, hips should be lowered until both knees were bent at a 90-degree angle. The front knee should be directly on top of the ankle, and the other should stay off the floor. The trunk should be kept straight during the test. This movement alternated between the right and left legs for one minute.

Ethics statement

Subjects were fully informed about the protocol and obtained their consent before testing. The protocol of this study has been approved by The Ethical Committee from the Dr. Cipto Mangunkusumo Hospital and the Faculty of Medicine Universitas Indonesia (approval letter number: 252/UN2.F1/ETIK/PPM.00.02/2021). This study has also been approved by the Education and Training of Army Command and Indonesia Ministry of Defense (approval letter number: B/3345/XI/2021).

Data Analysis

The data analysis was conducted in four steps. The first step was constructing a conceptual framework. The second step was to describe the characteristics of each group using SPSS.⁸ The third step evaluated the path analysis model and found the significant indicators to develop a physical fitness formula using Partial Least Square-Structural Equation Modeling (PLS-SEM). The final step was determining whether the formula was suitable for assessing physical fitness in running and wheeling tests.

The calculation of the minimum subjects for the PLS-SEM model was based on the Cohen system.⁹ In a study with six latent variables and a model target confidence level of at least 0.75, a minimum of 39 disabled subjects are required. The ratio between DS and NS was 1 : 2, so a minimum of 78 NS was required in this study.

Step One: Construct Conceptual Framework

The conceptual framework is constructed based on the theories and purpose of the study; to organize indicators of latent factors that affect physical fitness.^{5,6,10} (Figure 1).

Step Two: Descriptive Analysis

A descriptive analysis was conducted on the indicators of the research subjects, such as age, height, weight, systolic and diastolic blood pressure, maximum heart rate based on age, maximum pulse during field testing, oxygen saturation, blood glucose level, hemoglobin, distance running and/or wheeling, push-ups and lunges per minute, the distance of 2 kg ball-thrown, Cooper score for running test, and VO2max prediction results using the existing formula (not using CPET).

Step Three: PLS-SEM Analysis^{11,12}

SEM analysis is used to determine the physical fitness value of TNI soldiers by considering several influencing factors. This step is only applied to the wheeling and running test for normal subjects and aims to obtain models and formulas from significant indicators.

Step Four: Testing the Formula

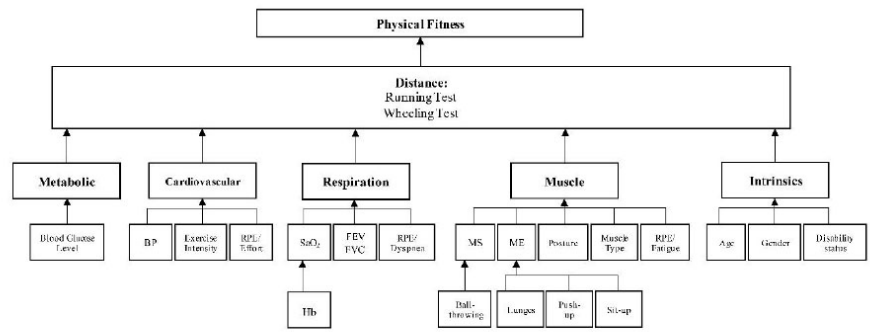
We compared the formula created in step 2 for NS (wheeling and running test) and DS (wheeling test) using SPSS.

RESULT

There was no significant difference in the characteristics of NS and DS, such as age, weight, height, body mass index, systolic and diastolic blood pressure, hemoglobin, and blood glucose level; thus, the subjects in both groups were comparable (Table 1).

Table 2 showed the results of the distance, intensity, VO2max prediction value, ball throwing tests, push-ups, and lunges. The average distance, intensity, and VO2max prediction value were all greater in the running test than in the wheeling test.

Several latent factors had path coefficients with values of -1 to 1 and a significant T-value of more than 1.96 (Table 3). The R-square obtained from the PLS-SEM analysis was 0.976 (Figure 2). Latent factors and indicators that meet all the criteria and are the most significant contributing factors were performance (path coefficient=1.1), the distance traveled (path coefficient value=0.98), test methods (path coefficient value=0.97), ball throwing (coefficient value=-0.169) and age (path coefficient value of -0.093). (Table 3).



BP = blood pressure; FEV = forced expiratory volume; FVC = forced vital capacity; Hb = haemoglobin; RPE = rate perceived exertion; ME = muscle endurance; MS = muscle strength

Figure 1. Conceptual Framework.

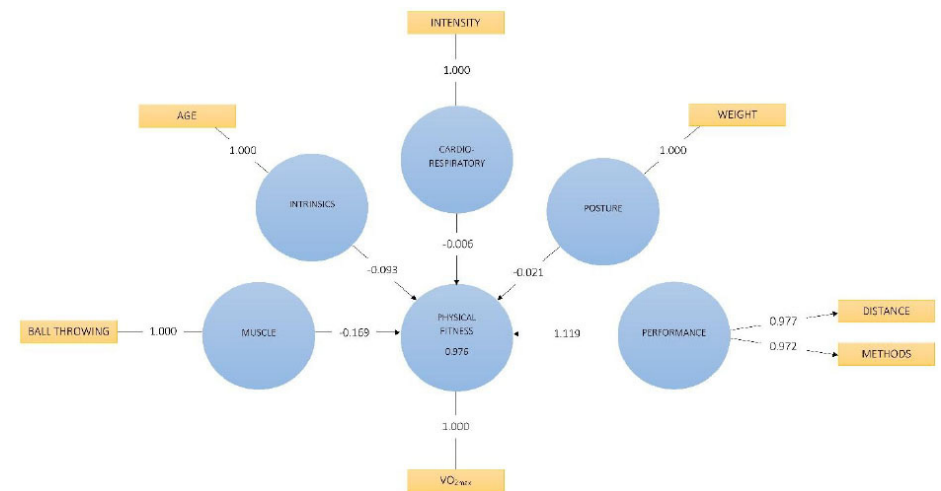


Figure 2. PLS-SEM Model for Physical Fitness Assessment.

Formula:

$$Physical\ Fitness = \{1.1 \times (0.98 \times distance^*) + (0.97 \times method\ value^{**})\} - (0.17 \times muscle\ strength^{***}) - (0.093 \times age)$$

*) Distance traveled during running or wheeling test (meter)
 **) The running test method value is entered as 1, and the wheeling test method value is entered as 2.
 ***) The value of wheeling muscle strength is obtained from the ball-throwing test, while the value of running muscle strength can be determined by multiplying the result of the ball-throwing test by 2.

DISCUSSION

The present study investigated factors and indicators that significantly influence physical fitness in order to develop a formula for assessing the physical fitness of DS. We conducted this study on NS and DS to establish normative physiological responses to the tests and compare the results when the formula is applied to DS.

Analysis of this study begins with

the proposed conceptual framework, which is then utilized to create a PLS-SEM model. Cardiovascular, respiratory, muscle, metabolic, and intrinsic factors affect the distance achieved in the wheeling and running test results.^{3,13} In the conceptual framework, the values of factors affecting the wheeling and running distances are derived from several indicators such as cardiovascular factors, including blood pressure, heart rate, and RPE Borg's score.

Table 1. Characteristics of the subjects (n=154).

Characteristics	Normal soldiers n = 104	Injured soldiers n = 50
Age (yr)	32 ± 9	32 ± 7
Weight (kg)	69.7 ± 8.2	72.18 ± 10.55
Height (cm)	170 ± 4.1	169.6 ± 4.0
BMI (kg/m ²)	24.22 ± 2.5	24.67 ± 5.0
Systolic BP (mmHg)	121 ± 11.5	123.86 ± 13.5
Diastolic BP (mmHg)	7.8 ± 9.0	78.92 ± 7.4
Hemoglobin (g/dL)	15.0 ± 1.3	14.9 ± 1.1
Blood glucose level (GDS) (g/dL)	95.8 ± 17.1	103.1 ± 45.4

Table note: Data were presented as mean ± standard deviation for normal distribution and median (minimum-maximum) for not normal distribution. There were no significant difference in characteristics between normal and injured soldiers groups.

Table 2. Results of Physical Fitness Tests on NS and DS.

Indicators	Normal Soldiers n = 104		Disabled Soldiers n = 50
	Running test	Wheeling test	Wheeling test
Distance travelled (meter)	2488 ± 289	1466 ± 201	1349 ± 261
Intensity	102 ± 2	78 ± 7	81 ± 9
VO _{2max} prediction value	44.3 ± 6.5	21.5 ± 4.5	18.8 ± 5.8
Ball throwing	6.2 ± 0.8		6 ± 1.1
Push-ups	49 ± 10		38 ± 12
Lunges	50 ± 5		-

Table 3. Path coefficient and T-statistics value of latent factors.

Latent Factor	Path Coefficient	T-Statistics
Intrinsics	-0.093	6.68*
Cardiorespiratory	-0.006	0.196
Muscle	-0.169	6.77*
Performance	1.119	32.76*
Posture	-0.021	1.55

*) Significant value (>1,96)

Table 4. Category of Physical Fitness Value based on PLS Formula.

Category	Physical Fitness Value of NS Based on PLS Formula	
	Running Test	Wheeling Test
Poor	0 – 2380	0 – 1397
Fair	2380 – 2586	1397 – 1506
Average	2586 – 2802	1506 – 1615
Good	2802 – 2973	1615 – 1786
Excelent	≥ 2973	≥ 1786

Moreover, O₂ saturation, HB, FEV, FVC, and Borg's dyspnea score are respiration indicators, while muscle has endurance, strength, posture, muscle type, and Borg's fatigue score as well indicators. The muscle strength indicator value was derived from the ball throwing test score, while the muscle endurance indicator was derived from the lunges, push-ups, and sit-ups test scores. The indicators of intrinsic factors are age and the presence or absence of a disability.

By using the conceptual framework and the derived indicator values, a PLS-SEM-based multivariate analysis was performed to identify a model with the highest endogen factor (Y) value (*R-square* = 0.976) (Figure 2). In this study, PLS is utilized to simultaneously test the measurement model (relationships between indicators and their corresponding constructs) and the structural model (relationships between constructs) and to use SEM to determine if the constructed model is

valid.¹⁴

The first step in evaluating the measurement model is the validity test.^{11,14} There are 17 indicators tested in this study, namely: age, age category, distance traveled, test methods, blood pressure, exercise intensity, body weight, height, Body Mass Index (BMI), ball throwing test, leg strength (equation obtained from ball throwing test), push-ups, lunges, blood glucose level, hemoglobin level, Borg scale RPE value (effort, dyspnea and arm or leg fatigue), Cooper's score for the 12-minute running test, and VO_{2max} prediction value.

Of the 17 indicators, 11 have a loading factor value of more than 0.7^{11,14}, age, distance traveled, test methods, exercise intensity, body weight, BMI, ball throwing test, blood glucose level, Borg's dyspnea score, Cooper score, and VO_{2max} prediction value.

Of the 11 loading factors selected, it turns out that eight indicators have an Average Variance Extracted (AVE) value greater than 0.5. AVE value of more than 0.5 means that these indicators are significant for the physical fitness test. This study's cutoff point for AVE and cross-loading is 0.9, meaning that the indicator and latent factor strongly correlated with physical fitness.^{11,14}

Cross-loading means that each indicator is appropriate for each latent variable to obtain the most significant value for endogen variables (Y).^{11,14} For example, the weight with a value of 1,000 in the latent variable posture is unsuitable when placed in the latent variable muscle because it only has a value of 0.019.

The next step is to evaluate the model structure:

1. R-square is the value of the endogen variable, in this case, Physical fitness. The R-square value in this study is 0.976, indicating that the indicators included in this multivariate model can account for 97.6% of the variance, indicating a significant correlation with physical fitness.
2. The path coefficient value indicates the variable's direction, with values from -1 to 1. The path coefficient value will be used as a coefficient in the developed formula.

3. The T-statistics test was performed to analyze the inner model. A value higher than 1.96 is considered significant. Three latent components have significant T-statistical values: performance, muscle, and intrinsic.

Performance has a path coefficient value of 1.1, consisting of 2 indicators: the distance traveled (path coefficient value = 0.98) and the test methods (path coefficient value = 0.97). Muscle has a path coefficient value of -0.169, consisting of ball throwing as an indicator. Intrinsic have a path coefficient value of -0.093 consisting of 1 indicator, namely age.

The test method's value for the running and wheeling test was based on the preliminary study. The VO₂max results of the wheeling test are 46-47% of the running test. The comparison of VO₂max between wheeling and running is 1:2; thus, the running test method value is 1, and the wheeling test method value is 2.^{10,15}

Muscle evaluation consists of two aspects: strength and endurance. Muscle strength is represented by arms and trunk, which is tested by a ball throwing test. Arm muscle endurance was tested with push-ups, while leg endurance was tested with lunges.^{5,6} This study shows that muscle strength has a more significant outer loading value than endurance; therefore, the value of the ball throwing test results is used in the physical fitness formula.

Ball throwing is a feasible test for both normal and disabled subjects. Muscle strength in the wheeling test is obtained from the value of the ball throwing test, which measures the strength of the arm muscles. The strength of the leg muscles during the running test can be assessed by a ball kicking test. The 2-kg ball kicking test is impractical and can lead to injuries; this study tries to examine this value by doing an equation from the ball throwing test. The equation was derived from the basic physics formula:¹⁶

$$W = F \times s$$

$W = \text{work (J)}$

$F = \text{force (N)}$

$s = \text{distance (m)}$

With the ratio of arm strength : leg strength = 1 : 2, leg muscle strength can be determined by multiplying the result of

the ball-throwing test by 2.¹⁷

From all steps above, it can be concluded that the physical fitness test has several major contributing factors: distance, test method, muscle strength, and age. The formula's coefficient is the path coefficient's value (Table 3).

This formula was confirmed by comparing the number of subjects in each category of running and wheeling tests on normal subjects. From the formulas applied to the normal subjects, five categories are made based on the 20th, 40th, 60th, and 80th percentiles, as shown in Table IV. The Wilcoxon test was carried out from this categorization and showed no significant difference ($P = 0.840$) between the running and wheeling tests on normal subjects.

The results of the formula application followed by the categorization of the wheeling test for disabled subjects are shown in Table IV. From the PLS formula result, there was a significant difference ($P = 0.000$) between the results of the wheeling test on the NS and DS. The average physical fitness of DS is still lower than NS. This result may be since it is difficult for DS to maintain or enhance their physical activity following the injury, which affects their overall health status.¹⁸ Rehabilitation programs with regular and adequate exercise will significantly increase functional capacity.^{5,19} Therefore, an integrated rehabilitation program must increase DS's physical fitness to return to duty.

The performance component has the highest T-significance value (32.76), indicating a substantial relation between its two indicators (distance and method) and physical fitness. The distance analysis in this study refers to the Cooper test, a military physical test standard. The Cooper test evaluates VO₂max by calculating the distance covered during a 12-minute running test and a constant.²⁰ However, the Cooper test and its VO₂max calculation method can only be applied to the running test. The physical fitness formula developed in this study can also be applied to the wheeling test. When the wheeling test distance is entered into the formula, it will generate the same physical fitness category as the running test distance.

The method is another performance indicator that strongly correlates to physical fitness. As mentioned above, the test method's value is obtained based on the previous theory of the VO₂max ratio of the running test compared to the wheeling test. VO₂max is the maximum rate of oxygen consumption during incremental exercise.²¹ Exercise stimulates the sympathetic nervous system and elicits an integrated response from the body; this response helps maintain an optimal state of homeostasis in response to increased physical, respiratory, cardiovascular, and metabolic demands. The circulatory, respiratory, and muscular systems contribute most to hemostasis during exercise.^{3,13,22} When a person performs a high-intensity physical activity, the cardiovascular, respiratory and musculoskeletal system workload reaches 90%, 65%, and 30%, respectively. This value suggests that the ability of the cardiovascular system to transport oxygen and nutrients to the muscle at a rate that supports aerobic metabolism is a major factor in determining maximum oxygen consumption (VO₂max).³

During exercise, oxygen is transported to and within skeletal muscle.²³ Alveolar ventilation can increase up to 20-fold to meet the increased oxygen demand and maintain homeostasis.²⁴ Physical exertion is believed to stimulate proprioceptors, receptors located in muscles, joints, and tendons that detect movement and stretching; proprioceptors generate a stimulation that may also trigger the brain's respiratory centers.²⁵

Cardiopulmonary Exercise Testing (CPET) is considered the gold standard for cardiorespiratory functional assessment.^{26,27} The CPET comprehensively examines the circulatory, respiratory, muscular, and metabolic systems during physical activity.²⁸ We could not use CPET due to the Covid-19 pandemic (the risk of transmission during the study had to be minimized). In addition, using CPET is not always practical due to the risks, equipment, cost and professional personnel required. As an alternative, we used the VO₂max prediction value as the benchmark in this study, thus, the resulting formula still refers to the gold standard of cardiopulmonary assessment.

In the PLS analysis, when the value of the cardiovascular factor was input alongside the value of the respiratory factor, the R-square value was greater than when the values were entered separately. From the physiology point of view, circulation and respiration work together toward the same goal; to acquire sufficient oxygen and deliver it to all the cells in the body.²⁹ Therefore, the analysis combined cardiovascular and respiratory factors (cardiorespiratory factors).

As we explained above regarding the limitations of using CPET, we included variables that are easier to assess and can represent the cardiorespiratory function during the running or wheeling test using non-gas-exchange data, such as exercise intensity. In this investigation, the cardiorespiratory factor did not significantly affect physical fitness (T-significant = 0.196), although one of the indicators, intensity, showed a significant loading factor (1,000). During the running test, there was no significant difference in the intensity reached by any of the subjects because all NS reached maximum intensity, which may explain why the intensity did not have a significant T-statistic value.

Muscle strength also has a significant T-statistics value (6.77) (Table 3). To acquire good analytical results in this study, we distinguished the measurement of muscle strength in the wheeling and running tests, as the type and strength of the muscles involved in those tests were different. The strength of leg muscles is double that of arm muscles. Thus, the muscle strength obtained from the ball-throwing test must be multiplied by two to estimate leg muscle strength on the running test.¹⁷

Arm muscles are classified as fast glycolytic muscles (Type IIB), which have higher myosin ATPase activity, contraction speed, glycogen levels, and anaerobic enzymes than leg muscles which are oxidative fast muscle groups (Type IIA).³⁰ Arm muscles also fatigued more quickly than the legs because the muscle fibers have fewer mitochondria, smaller capillaries, and lower myoglobin.³⁰ Muscle fatigue is a condition in which the muscles cannot perform the required physical activity. The intensity of the

workload determines this, the duration of the contraction, the type of metabolism involved (aerobic or anaerobic), the muscle composition, and the fitness level.³¹ This theory explained the findings in this study wherein early fatigue during the wheeling test caused the speed to decrease, resulting in less distance covered than the running test.

The indicator of muscle endurance (push-ups and lunges) was predicted to have a significant relation to physical fitness. However, the loading factor obtained is less than 0.7. This might occur because the number of repetitions measures the result of push-ups and lunges; the wheeling and running are measured by distance achieved (in meters), making it difficult to analyze the relationship between both results. The fact that the results of the muscle strength indicator (ball throwing test) had stronger relation to the running and wheeling test indicates that it might be easier to find a relation between results that use the same sort of measurement; in this case, distance. In addition, DS could not perform the lunges test; consequently, this indicator has a data gap. This condition might affect the PLS analysis of muscle endurance indicators.

Age, gender, and disability status are intrinsic variables that the subject cannot modify. Age indicates a significant T-statistic value (6.68) (Table III)—cardiopulmonary fitness declines with age. In the third and fourth decades of life, peak oxygen consumption per unit of time (VO₂peak) declines by 3% to 6% per decade. In addition, muscle strength and endurance both significantly impact fitness levels, and both deteriorate with age. These theories explain why age is an important indicator for determining the physical fitness.³²

In this study, PLS-SEM allowed all aspects of physical fitness to be included holistically in the analytic process; therefore, the results obtained are indicators that significantly affect the physical fitness assessment. Accordingly, the resulting formula can be implemented accurately and effectively in daily practice.

Study Limitation

This research was conducted during the Covid-19 pandemic, making it impossible

to use the CPET, the golden standard for VO₂max assessment. Due to the diversity of disabilities, it is necessary to do further research on the method or formula for evaluating physical fitness for other types of disabilities. The normal subjects in this study have similar characteristics and health status and have undergone the same training in the military; further research with a variety of subjects is necessary.

CONCLUSION

1. The physical fitness test has several major contributing factors based on PLS-SEM analysis: distance, test method, muscle strength, and age.
2. Formula derived:

$$\text{Physical Fitness} = \{1.1 \times (0.98 \times \text{distance}^*) + (0.97 \times \text{method value}^{**})\} - (0.17 \times \text{muscle strength}^{***}) - (0.093 \times \text{age})$$

*) Distance traveled during running or wheeling test (meter)

**) The running test method value is entered as 1, and the wheeling test method value is entered as 2.

**) The value of wheeling muscle strength is obtained from the ball-throwing test, while the value of running muscle strength can be determined by multiplying the result of the ball-throwing test by 2.

3. There is no significant difference in the number of normal subjects in each category between the running and wheeling tests. Therefore, the formula can be applied for both running and wheeling tests in NS or DS, and when applied to the same subject, it generates the same assessment category.

DISCLOSURE

Funding

None.

Author Contributions

EE contributed as principal investigator and author. NN contributed giving the design of the study. TAP contributed to analyzing the data. DISS, DT, LTM, and SAN were evaluated to suggest writing improvement. AA contributed to preparing and editing the manuscript.

Conflict of Interest

None.

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