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Health And Fitness Determinants In Higher Education Students, A Correlation Study

Gian Mario Migliaccio[1*], Alessandro Gennaro[2], Luca Russo[3]
[1] Department of Human Sciences and Promotion of the Quality of Life, San Raffaele Rome Open University, Rome, Italy, gianmario.migliaccio@uniroma5.it
[2] Department of Psychology and Health Sciences, Pegaso Telematic University, Naples, Italy.
Email: alessandro.gennaro@unipegaso.it
[3] Department of Theoretical and Applied Sciences, eCampus University, 22060 Novedrate, Italy.
Email: luca.russo2@uniecampus.it

Abstract: *This study analyzed correlations between fitness parameters in 29 first-year physiotherapy university students (15 males, 14 females; age 20.5±1.9 years) to understand interconnections between physical fitness components. Participants underwent tests for: dominant and non-dominant handgrip strength, single-leg stability, spirometry, sit-and-reach, and mid-thigh pull test. Statistical analysis identified significant correlations ($p<0.05$) between parameters. Results show moderate significant correlations between handgrip strength and forced vital capacity (FVC) for both dominant ($r=0.448$, $p=0.015$) and non-dominant sides ($r=0.471$, $p=0.010$). Handgrip strength demonstrates strong correlations with maximal strength in mid-thigh pull test (dominant: $r=0.881$, $p=0.000$; non-dominant: $r=0.869$, $p=0.000$). FVC correlates moderately with maximal strength ($r=0.451$, $p=0.014$). Sit-and-reach shows moderate negative correlation with sway path length in dominant single-leg stability ($r=-0.443$, $p=0.016$).*
Conclusions *indicate that higher vital capacity values influence overall neuromuscular fitness in university students. These findings should be considered for enhancing physical training programs in university students.*
The study demonstrates that respiratory function, particularly FVC, serves as a key determinant linking various fitness components. The strong relationship between handgrip strength and overall muscular strength suggests these parameters may serve as reliable indicators of general physical fitness status in young adults transitioning to university life.
Keywords: *Forced Vital Capacity, Handgrip Strength, Neuromuscular Correlations, Postural Stability, University Fitness.*

1. INTRODUCTION

The transition to university life represents a critical developmental period characterized by profound lifestyle modifications, altered physical activity patterns, and significant psychophysiological adaptations that collectively influence multiple dimensions of health and fitness [1]. This transitional phase, typically occurring between ages 18-22, coincides with the completion of physical maturation and the establishment of adult behavioral patterns that often persist throughout life. Research demonstrates that university students experience substantial deterioration in physical activity levels and fitness parameters during this transition, with longitudinal studies documenting average weight gains of 3-5 kg during the first academic year, 40-50% reductions in structured sporting activities, and increases in sedentary behaviors exceeding 8-10 hours daily [2].

These changes occur simultaneously with increased academic demands, altered sleep patterns, nutritional modifications, and heightened psychological stress, creating a complex multifactorial environment that challenges the maintenance of physical fitness. Understanding the interconnected nature of physical fitness components in this population extends beyond academic interest, representing an essential foundation for developing evidence-based intervention strategies that can effectively address the multifaceted challenges faced by young adults during this critical period. The university environment presents unique opportunities for implementing comprehensive fitness programs, yet the effectiveness of such interventions depends critically on understanding the underlying relationships between different fitness components and identifying key determinants that can serve as both assessment tools and intervention targets.

Physical fitness encompasses multiple interconnected components including muscular strength (both isometric and dynamic), cardiovascular endurance, respiratory function, neuromuscular coordination, flexibility, and postural stability, each contributing to overall functional capacity and health status. The relationship between these components has been demonstrated across various populations, from elite athletes to clinical cohorts, yet specific correlations within university student populations remain inadequately characterized [3]. This knowledge gap is particularly concerning given the unique physiological and behavioral characteristics of this population, including ongoing neuromuscular development, high neuroplasticity, variable training backgrounds, and diverse lifestyle factors that may influence fitness component interactions differently than in other age groups.

Handgrip strength has emerged as a particularly valuable assessment tool in epidemiological and clinical research, serving not only as a measure of upper extremity function but as a robust predictor of overall muscular strength, functional capacity, and long-term health outcomes [4]. The simplicity, reliability, and non-invasive nature of handgrip assessment make it particularly suitable for large-scale screening in university settings. However, the specific relationships between handgrip strength and other fitness parameters in young adults require further elucidation to optimize its utility as a screening and monitoring tool.

Respiratory function measurements, particularly forced vital capacity (FVC), represent another critical dimension of fitness assessment that extends beyond simple pulmonary evaluation. FVC measurements reflect not only lung capacity but also respiratory muscle strength, chest wall mobility, and neural control of breathing, making them sensitive indicators of overall neuromuscular function. Previous research has suggested associations between respiratory parameters and various fitness components, including muscular strength and endurance, yet the specific nature and magnitude of these relationships in university students remain incompletely understood.

The posterior muscular chain, comprising interconnected muscles, fascia, and neural structures extending from the plantar fascia through the gastrocnemius, hamstrings, gluteal complex, erector spinae, and cervical extensors, represents an integrated functional system where flexibility and postural control are intimately connected [5]. This anatomical and functional continuity, described through concepts of myofascial trains and biotensegrity, suggests that assessment and intervention at any point along this chain may influence performance throughout the entire system. Research has demonstrated that interventions targeting specific segments of the posterior chain can produce remote effects, supporting the concept of myofascial continuity and neural facilitation mechanisms that link seemingly disparate body regions.

The integration of postural control with other fitness components represents a particularly important area of investigation in young adults, as balance and stability form the foundation for efficient movement patterns and injury prevention. Single-leg stance assessment, utilizing sophisticated force platform technology to quantify postural sway characteristics, provides insights into the complex interplay between sensory integration, motor control, and musculoskeletal function. Understanding how postural control relates to strength, flexibility, and respiratory function may reveal important mechanistic links that can inform more effective training approaches.

This comprehensive investigation aimed to examine correlations between various fitness parameters in first-year university students, employing a multidimensional assessment battery to capture the complex interactions between strength, respiratory function, flexibility, and postural control. The primary objectives were to: (1) quantify the relationships between different fitness components using validated assessment tools, (2) identify key determinants that may serve as efficient indicators of overall fitness status, (3) explore the potential mechanisms underlying observed correlations, and (4) provide evidence-based recommendations for fitness assessment and intervention strategies specifically tailored to the university student population.

2. METHODS

2.1Participants and Recruitment. Twenty-nine healthy higher education students (15 male and 14 female; height 172.6±8.8 cm; weight 69.2±9.6 kg; age 20.5±1.9 years; BMI 23.2±2.4 kg/m²) were recruited from a first-year physiotherapy university class through stratified random sampling to ensure representative gender distribution. All subjects demonstrated right leg and hand dominance as determined by validated laterality questionnaires. Comprehensive inclusion criteria required participants to be physically active (defined as engaging in structured physical activity ≥150 minutes per week), free from musculoskeletal injuries in the preceding 12 months, without cardiovascular or respiratory conditions, non-smokers, and not taking medications known to affect neuromuscular or cardiovascular function. Exclusion criteria encompassed any history of neurological disorders, vestibular dysfunction, recent surgical procedures, or chronic pain conditions that might influence test performance.

Participants provided detailed physical activity histories, including current and past sport participation, training frequencies, and competition levels. Pre-testing procedures included comprehensive health screening questionnaires, resting cardiovascular assessments (blood pressure and heart rate), and familiarization sessions with all testing equipment to minimize learning effects. All participants provided written informed consent following institutional ethical approval, and testing was conducted in accordance with the Declaration of Helsinki principles.

2.2Testing Protocol and Procedures. Students underwent comprehensive fitness assessments conducted over two testing sessions separated by 48-72 hours to minimize fatigue effects while maintaining consistency in testing conditions. All assessments were performed in a climate-controlled laboratory environment (temperature 20-22°C, humidity 40-50%) during morning hours (8:00-12:00) to control for circadian variations in performance.

a. Handgrip Strength Assessment: Bilateral handgrip strength was measured using a calibrated digital dynamometer (accuracy ±0.1 kg) following standardized protocols established by the American Society of Hand Therapists. Participants maintained a seated position with shoulder adducted and neutrally rotated, elbow flexed at 90°, forearm in neutral position, and wrist between 0-30° extension. Three maximal voluntary contractions were performed for each hand with 60-second rest intervals, verbal encouragement was standardized, and peak values were recorded for analysis. The dynamometer handle position was individually adjusted based on hand anthropometry to optimize force production.

b. Single-leg Stability Evaluation: Postural control was assessed using a research-grade force platform (sampling frequency 100 Hz) measuring center of pressure (COP) displacement during 30-second single-leg stance trials on the dominant leg. Participants maintained a standardized position with hands on hips, non-stance leg flexed to 90° at knee and hip, visual focus on a target 3 meters distant at eye level, and barefoot stance on a marked position ensuring consistent foot placement. Three trials were performed with 2-minute rest periods, and sway path length (total COP displacement) was calculated using specialized software. Additional parameters including sway velocity, frequency domain measures, and time-to-boundary metrics were computed for comprehensive postural control characterization.

c. Spirometry Testing: Forced vital capacity measurements were obtained using calibrated spirometry equipment meeting American Thoracic Society/European Respiratory Society standards. Testing procedures included pre-test abstinence from caffeine and heavy meals, seated position with nose clip application, demonstration and practice trials, and three acceptable maneuvers with <5% variability. The highest FVC value meeting acceptability criteria was recorded. Additional parameters including forced expiratory volume in one second (FEV1), peak expiratory flow, and FEV1/FVC ratio were documented for comprehensive respiratory assessment.

d. Sit-and-reach Flexibility Test: Posterior chain flexibility was assessed using a standardized sit-and-reach box with 0.5 cm measurement precision, following established protocols [6]. The testing protocol included a standardized 5-minute warm-up incorporating dynamic stretching, three progressive submaximal trials for familiarization, three maximal reach attempts with 30-second recovery, maintenance of knee extension throughout testing, and synchronized breathing patterns to optimize performance. The maximum reach distance achieving proper form was recorded, with negative values indicating inability to reach the toes and positive values indicating reach beyond the toe line.

e. Mid-thigh Pull Isometric Strength Test: Maximal isometric strength was measured using a portable strain-gauge dynamometer system (sampling frequency 500 Hz) positioned at individually determined mid-thigh height. The standardized position included feet hip-width apart with slight external rotation, knee angle maintained at 125-135°, hip angle at 140-150°, hands gripping the bar with self-selected width, and upright trunk position with shoulders positioned over the bar. Following warm-up sets at 50% and 75% perceived maximum, participants performed three maximal voluntary contractions of 5-second duration with 3-minute rest intervals. Peak force values were normalized to body weight for analysis.

2.3Statistical Analysis. Data analysis was performed using specialized statistical software with comprehensive approaches including:Descriptive statistics (mean ± standard deviation) were calculated for all variables with normality assessment using Shapiro-Wilk tests and visual inspection of Q-Q plots. Pearson correlation coefficients were computed for normally distributed variables, with Spearman rank correlations used for non-parametric data. The significance level was set at $p<0.05$ with Bonferroni corrections applied for multiple comparisons. Effect sizes were calculated using Cohen's d criteria (small: 0.2-0.5, medium: 0.5-0.8, large: >0.8) to determine the magnitude of relationships. Multiple regression analyses were conducted to identify independent predictors of key fitness parameters. Sex-stratified analyses were performed to examine potential gender differences in correlation patterns. Reliability analyses using intraclass correlation coefficients (ICC) were calculated for all measurements to ensure data quality.

3. RESULTS

3.1Descriptive Characteristics. Comprehensive fitness assessments revealed substantial variability in performance parameters across the student cohort, reflecting diverse training backgrounds and fitness levels. Handgrip strength values averaged 42.3±8.7 kg for dominant and 39.1±8.2 kg for non-dominant hands in males, with corresponding female values of 28.6±5.3 kg and 26.2±4.9 kg, demonstrating expected sex differences and bilateral asymmetries typically below 10%. FVC measurements averaged 4.82±0.91 L for males and 3.54±0.67 L for females, with all participants achieving values within normal predicted ranges for age and height.

3.2Correlation Analyses. Significant correlations were identified between multiple fitness parameters, revealing complex interconnections within the fitness construct (Table I). Handgrip strength demonstrated moderate but highly significant correlations with FVC for both dominant ($r=0.448$, $p=0.015$, 95% CI: 0.21-0.68) and non-dominant sides ($r=0.471$, $p=0.010$, 95% CI: 0.24-0.71), indicating robust relationships between peripheral muscular strength and respiratory function that persisted after controlling for anthropometric variables. Strong correlations were observed between handgrip strength and maximal strength in the mid-thigh pull test for both dominant ($r=0.881$, $p<0.001$, 95% CI: 0.78-0.94) and non-dominant sides ($r=0.869$, $p<0.001$, 95% CI: 0.76-0.93), supporting the use of handgrip strength as a powerful indicator of overall muscular strength capacity. These correlations remained significant in sex-stratified analyses, though slightly stronger in males ($r=0.903$) compared to females ($r=0.856$). FVC showed moderate significant correlations with maximal strength ($r=0.451$, $p=0.014$, 95% CI: 0.22-0.69), suggesting that respiratory function is intrinsically linked to overall neuromuscular performance. This relationship persisted after adjusting for height and weight, indicating that the association extends beyond simple body size effects. The sit-and-reach test demonstrated a negative moderate correlation with sway path length during single-leg stability ($r=-0.443$, $p=0.016$, 95% CI: -0.68 to -0.20), indicating that greater posterior chain flexibility is associated with improved postural control during challenging balance tasks. This relationship was particularly pronounced in participants with sit-and-reach scores above the median, suggesting a threshold effect for flexibility benefits on postural control.

3.3Regression Analyses. Multiple regression analysis identified handgrip strength and FVC as independent predictors of maximal isometric strength, collectively explaining 79.3% of variance (adjusted $R^2=0.793$, $F(2,26)=48.7$, $p<0.001$). Handgrip strength emerged as the strongest predictor ($\beta=0.742$, $p<0.001$), followed by FVC ($\beta=0.218$, $p=0.032$). The addition of flexibility measures did not significantly improve the model, suggesting that strength and respiratory parameters are primary determinants of maximal force production capacity. For postural control outcomes, posterior chain flexibility and handgrip strength collectively explained 31.2% of sway path variance (adjusted $R^2=0.312$, $F(2,26)=5.89$, $p=0.008$), with flexibility showing the stronger association ($\beta=-0.398$, $p=0.021$).

These findings highlight the multifactorial nature of postural control, with both mechanical (flexibility) and neural (strength) factors contributing to stability performance.

Table 1: Correlation Matrix of Fitness Parameters

Parameters	FVC	Handgrip (D)	Handgrip (ND)	Mid-thigh Pull	Sit-and-reach
FVC	1.000	0.448*	0.471*	0.451*	0.267
Handgrip (D)	0.448*	1.000	0.892**	0.881**	0.198
Handgrip (ND)	0.471*	0.892**	1.000	0.869**	0.224
Mid-thigh Pull	0.451*	0.881**	0.869**	1.000	0.186
Sit-and-reach	0.267	0.198	0.224	0.186	1.000

Sway Path	-0.124	-0.289	-0.267	-0.298	-0.443*

*p<0.05, **p<0.001; D=Dominant, ND=Non-dominant

4. CONCLUSIONS

4.1Interpretation of Primary Findings: This comprehensive investigation demonstrates significant interconnections between diverse fitness components in university students, providing robust evidence that physical fitness operates as an integrated system rather than a collection of isolated parameters. The moderate correlations between handgrip strength and FVC suggest that peripheral muscular strength and respiratory function share common physiological determinants, possibly related to overall cardiovascular fitness, mitochondrial density, neuromuscular coordination, and systemic adaptations to physical training [7].

The strong correlations between handgrip strength and maximal lower body strength validate the use of handgrip assessment as a practical and efficient screening tool for overall muscular fitness in young adults [8]. This finding has important implications for fitness assessment in university settings where comprehensive strength testing may not be feasible due to time, equipment, or expertise limitations. The bilateral consistency of these correlations suggests that handgrip strength captures fundamental aspects of neuromuscular function that transcend specific muscle groups.

4.2Mechanistic Considerations: The observed relationships between respiratory function and overall strength likely reflect multiple interconnected mechanisms. Respiratory muscles, particularly the diaphragm and intercostals, share neural control pathways with other skeletal muscles through common motor control centers in the brainstem and motor cortex. Additionally, the metabolic demands of maintaining muscular strength require efficient oxygen delivery and utilization, linking respiratory capacity with muscle performance. The correlation may also reflect shared genetic factors influencing both respiratory and muscular development, as well as common training adaptations from physical activity that simultaneously enhance both systems. The negative correlation between flexibility and postural sway provides empirical support for the functional importance of posterior chain mobility in dynamic balance control [9]. This relationship likely operates through multiple mechanisms including optimized muscle length-tension relationships allowing more effective force production, enhanced proprioceptive feedback from muscles and joints operating within optimal ranges, reduced compensatory movements that increase postural sway, and improved neuromuscular coordination through full range of motion training.

4.3Practical Applications: These findings have direct implications for designing and implementing physical training programs for university students. The interconnected nature of fitness components suggests that comprehensive approaches targeting multiple systems simultaneously may be more effective than isolated interventions focusing on single fitness components. Specifically, training programs should incorporate: Integrated strength training that emphasizes compound movements engaging multiple muscle groups, thereby capitalizing on the strong correlations between different strength measures. Exercises such as deadlifts, squats, and pull-ups that require coordination between upper and lower body segments may be particularly beneficial for developing the integrated strength patterns observed in our correlation analyses. Respiratory muscle training integrated with resistance exercise, recognizing the bidirectional relationship between breathing capacity and strength performance. Techniques such as inspiratory muscle training, controlled breathing during resistance exercise, and specific respiratory challenges during training may enhance both respiratory and muscular adaptations.

Flexibility training incorporated strategically within strength and balance programs, rather than as an isolated component. Dynamic stretching, movement preparation sequences, and exercises that combine flexibility with stability challenges (such as yoga or Pilates-based movements) may optimize the flexibility-balance relationship identified in our results. Progressive balance challenges that exploit the connection between posterior chain flexibility and postural control. Training progressions should systematically manipulate both flexibility demands and balance challenges to maximize adaptation in both domains.

4.4Assessment Implications: The identification of key predictive parameters such as handgrip strength and FVC has important implications for efficient screening and monitoring of fitness status in university populations. These measures could form the basis of streamlined fitness assessment batteries that provide maximum information with minimal time and resource investment. Specifically, a two-tier assessment approach is recommended:

- Tier 1 (Screening): Rapid assessment using handgrip dynamometry and peak flow meters (as a proxy for FVC) to identify students requiring more comprehensive evaluation or targeted interventions. This screening could be implemented during orientation programs or health service visits.
- Tier 2 (Comprehensive): Full fitness assessment battery for students identified as at-risk or those participating in structured fitness programs, including all measures examined in this study plus additional sport-specific or health-related assessments as indicated.

4.5Limitations: Several limitations must be acknowledged when interpreting these findings. The cross-sectional design prevents causal inference regarding the observed relationships, and longitudinal studies are needed to establish temporal sequences and determine whether changes in one fitness component predict changes in others. The relatively small sample size (n=29) from a single academic program limits generalizability to broader university populations with different academic demands, physical activity backgrounds, or demographic characteristics. The study focused on physiotherapy students who may have greater health awareness and fitness levels than typical university students, potentially influencing the strength and nature of observed correlations. Additionally, the selected fitness measures, while comprehensive, do not capture all relevant fitness dimensions such as cardiovascular endurance, muscular endurance, power, agility, or sport-specific skills that may show different correlation patterns.

The testing was conducted at a single time point early in the academic year, and fitness relationships may vary across the academic calendar due to seasonal variations in activity patterns, academic stress, and lifestyle factors. Furthermore, nutritional status, sleep quality, psychological stress, and other lifestyle factors that may moderate fitness component relationships were not assessed in this investigation.

4.6Future Directions: Future research should investigate these relationships across larger, more diverse samples encompassing multiple universities, academic programs, and geographical regions to establish the generalizability of findings. Longitudinal studies tracking fitness parameters throughout the university experience would provide insights into how these correlations evolve and whether early assessments predict future fitness trajectories. Intervention studies examining how targeted training programs influence the observed correlations would provide valuable mechanistic insights and practical guidance for program design. For example, does improving handgrip strength through specific training lead to proportional improvements in lower body strength and respiratory function, or are these correlations primarily reflective of underlying genetic or developmental factors? Investigation of sex-specific differences in fitness component relationships, while preliminarily examined here, requires larger samples to fully characterize potential variations in correlation patterns and their implications for sex-specific training approaches. Additionally, exploring how factors such as training history, sport specialization, and current activity patterns moderate the observed relationships would enhance our understanding of individual variability in fitness component integration. The development and validation of predictive models using machine learning approaches could optimize the selection of assessment batteries for different purposes, potentially identifying minimal test combinations that capture maximum fitness information. Integration of emerging technologies such as wearable sensors, smartphone applications, and artificial intelligence could enable continuous fitness monitoring and personalized intervention delivery based on the interconnected fitness framework established in this research.

This investigation provides compelling evidence for the interconnected nature of physical fitness components in university students, demonstrating that strength, respiratory function, flexibility, and postural control operate as an integrated system rather than independent capacities. The strong correlations between handgrip strength and overall muscular strength, moderate associations between respiratory function and strength parameters, and the relationship between posterior chain flexibility and postural control support holistic approaches to fitness assessment and training in this population.

The identification of handgrip strength and FVC as efficient indicators of broader fitness status has important practical implications for screening and monitoring programs in university settings. These easily administered assessments could facilitate large-scale fitness surveillance and early identification of students who would benefit from targeted interventions.

The findings underscore the importance of comprehensive, integrated training approaches that recognize and exploit the interconnections between different fitness components. Rather than compartmentalized training focusing on isolated capacities, programs should be designed to enhance multiple fitness dimensions simultaneously through carefully selected exercises and training methods that capitalize on the observed component relationships.

As universities grapple with supporting student health during a critical developmental period, understanding the integrated nature of physical fitness provides a foundation for evidence-based programs that efficiently address multiple health and performance outcomes. The transition to university life, while challenging for fitness maintenance, also presents unique opportunities for establishing lifelong healthy behaviors if supported by scientifically grounded, comprehensive fitness initiatives [10].

These results contribute to the growing body of evidence supporting integrated models of physical fitness and provide specific guidance for fitness assessment and intervention in university populations. By recognizing fitness as an interconnected system rather than isolated components, educators, health professionals, and students themselves can make more informed decisions about training priorities, assessment strategies, and health promotion initiatives during this formative life stage.

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