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Physical Activity Levels and Their Association with Psychological Resilience and Hardiness among Nurses Working in the ICU: A Cross-Sectional Correlational Study

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Abstract

Methods: This cross-sectional correlational study involved 225 nurses from ICUs of five teaching hospitals affiliated with Tabriz University of Medical Sciences. Participants were selected using proportional random sampling. Data were collected using the International Physical Activity Questionnaire (IPAQ-SF), Connor–Davidson Resilience Scale (CD-RISC), and Ahvaz Hardiness Inventory (AHI). Data were analyzed using SPSS v.21 with descriptive statistics, Pearson correlation, t-tests, ANOVA, chi-square, and multiple linear regression analyses.

Results: Most participants were female (78.2%), with a mean (SD) age of 35.23 (8.05) years. Mean resilience and hardiness scores were 60.10 (13.50) and 46.23 (8.54), respectively. Low physical activity levels were reported by 45.3% of nurses, while 20% were classified into the high physical activity category. Resilience was positively correlated with hardiness ($r = 0.53$, $P < 0.001$). Overall physical activity levels were not significantly associated with resilience or hardiness ($P > 0.05$). However, nurses with a previous sports history reported higher resilience and hardiness scores.

Conclusion: ICU nurse's demonstrated moderate psychological resilience and hardiness but insufficient physical activity. Although current physical activity levels were not significantly associated with psychological outcomes, a previous sports history was related to higher resilience and hardiness scores. These findings suggest that health-promotion strategies should consider both lifestyle habits and psychological support, while future longitudinal research is needed to clarify causal pathways.

Keywords: Physical Activity, Psychological Resilience, Hardiness, Critical Care Nursing, Intensive Care Units

Introduction

Nurses serve as the primary frontline caregivers within healthcare systems, holding an essential role in providing patient-centered care.¹ Although the nursing profession is intrinsically demanding, involving considerable levels of job-related stress and emotional strain, these challenging working conditions can adversely affect nurses' physical and psychological well-being and may reduce their overall quality of life.²

Nurses working in intensive care units (ICUs) are particularly vulnerable to substantial occupational stress due to the complex nature of critical patient care and demanding workplace environments.³⁻⁴ Accumulating evidence suggests that sustained occupational pressures can negatively impact nurses' physical and psychological well-being, which in turn may compromise job performance and the quality of patient care delivered.⁵ Physical activity is widely recognized as an important contributor to physical and psychological health. Regular physical activity has been associated with several favorable psychological outcomes, including lower perceived stress and anxiety, improved mood, and greater self-esteem.^{5,7} These associations may reflect a combination of physiological and psychosocial pathways.^{6,8} However, despite the physically demanding nature of intensive care units, where nurses spend considerable time standing and walking, evidence indicates that many nurses engage in limited physical activity during leisure time.^{7,8}

Although psychological resilience and hardiness are interrelated adaptive resources, they represent distinct theoretical constructs. Hardiness functions primarily as a protective personality disposition consisting of commitment, control, and challenge, which shapes how individuals initially appraise potential stressors. In contrast, resilience reflects a dynamic process of adaptation and recovery following exposure to adversity. Examining both constructs simultaneously allows for a more comprehensive assessment of nurses' psychological adaptation, distinguishing between enduring personality-based coping attitudes (hardiness) and dynamic recovery capacities (resilience) in high-stress ICU environments. Psychological hardiness, characterized by commitment, a sense of control, and viewing stressors as opportunities for growth, allows people to interpret demanding situations as surmountable rather than overwhelming.⁹⁻¹⁰ It fosters a distinctive mindset in individuals that influences how they manage diverse life challenges. Individuals with high hardiness demonstrate stronger emotional resilience and lower levels of perceived stress, acting as a safeguard against occupational pressures.¹⁰⁻¹¹ For example, nurses exhibiting greater psychological hardiness tend to be less affected by workplace bullying.¹⁰

Likewise, psychological resilience refers to an individual's capacity to adapt to and recover from adversity and demanding circumstances.¹²⁻¹⁵ Among nurses, higher resilience has been associated with favorable outcomes such as greater job satisfaction, self-efficacy, and psychological well-being.^{12,14,15} This quality assists individuals in preserving their problem-solving skills and fostering ongoing personal and career advancement, even when confronted with substantial demands.

Nurses possessing strong resilience exhibit enhanced clinical proficiency and are more adept at alleviating the mental burden of intense work settings, notably in ICUs.¹⁶⁻¹⁷

Previous research suggests physical activity may be associated with resilience and psychological hardiness through several biological and psychosocial pathways, including improved stress regulation, better sleep, mood, self-efficacy, and perceived control.¹⁴ Despite the critical role of nurses in healthcare systems, three important gaps remain in the current literature. First, previous studies have predominantly examined physical activity, resilience, and hardiness in isolation, neglecting their potential interrelationships. Second, despite the recognized benefits of physical activity, there is limited empirical evidence regarding the associations between physical activity levels, psychological resilience, and hardiness among nurses working in high-stress clinical environments such as ICUs.¹⁶⁻¹⁸ Third, contextual factors and socio-cultural barriers to physical activity reported among Iranian women may further compound these challenges among female nurses; however, empirical data on how these factors interact with psychological resources in the ICU setting remain scarce. Addressing these gaps is essential for developing evidence-based, context-sensitive interventions to support ICU nurses' well-being and, consequently, the quality of critical care. Therefore, this study aimed to evaluate physical activity levels, psychological resilience, and hardiness, and to analyze their associations among ICU nurses in teaching hospitals affiliated with Tabriz University of Medical Sciences. The findings may inform evidence-based interventions to promote nurses' health, optimize their professional performance, and ultimately improve the quality of critical care services. The purpose of this research includes the following:

- 1- To determine the levels of physical activity and the mean scores of psychological resilience and hardiness among ICU nurses.
- 2- To examine the association between the levels of physical activity, psychological resilience, and hardiness among ICU nurses.

Materials and Methods

Design and samples

This study employed a cross-sectional, descriptive-correlational design to evaluate physical activity levels, psychological resilience, and hardiness, as well as their interrelationships, among ICU nurses. Data were collected at a single time point, reflecting the cross-sectional nature of the study. This study recruited 225 nurses working in ICUs of five teaching hospitals affiliated with Tabriz University of Medical Sciences, located in East Azerbaijan Province, Iran. Proportional stratified random sampling strategy was used across the five hospitals. The sample size for each hospital was determined based on its proportion of the overall ICU nurse population. Simple random sampling was then performed within each hospital to select individual participants. The final sample distribution across the five hospitals was: Hospital Shohada (14, %6.3), Hospital Madani (85, %37.7), Hospital Emam Reza (48, %21.3), Hospital Sina (62, %27.5), and Hospital Talegani (16, %7.2). The sample size was estimated based on the correlation coefficient obtained from a pilot study conducted among 30 ICU nurses. The sample size was calculated using GPower software (version 3.1.9.7). Based on an expected two-tailed correlation coefficient ($r = 0.195$) between physical activity and psychological variables, with a significance level ($\alpha = 0.05$) and a

statistical power ($1 - \beta = 0.80$) a minimum sample size of 204 participants was required. To account for a potential non-response rate of approximately 10%, the target sample size was increased to 225 nurses. Additionally, for the planned multiple linear regression analyses involving up to 5 predictor variables, a minimum sample size of 90 participants was required according to Green's rule ($N \geq 50 + 8m$, where m is the number of predictors). Thus, the final sample size of 225 provided more than adequate statistical power for both bivariate correlations and multiple linear regression models.

A list of eligible nurses working in the ICUs was obtained from the nursing office of each hospital. Each nurse was assigned a unique number. Participants were then selected through computer-generated simple randomization using the random sequence generator available at <https://www.random.org/sequences>. This approach ensured that all eligible nurses had an equal probability of selection and minimized selection bias. Sampling continued until the required sample size was achieved. To reduce the potential influence of confounding variables, several demographic and occupational characteristics including age, gender, marital status, education level, work experience, weekly working hours, shift pattern, and previous sports history were collected and statistically examined during the analysis phase.

Inclusion criteria were having at least a bachelor's degree in nursing, having a minimum of six months of work experience in the ICU, no history of psychiatric disorders (e.g., depression or psychotic disorders) based on medical records, and no physical disabilities or movement restrictions based on medical records. Missing data were evaluated separately for each measurement instrument. Questionnaires with more than 10% missing items on any individual scale were considered incomplete and excluded from the final analysis via listwise deletion. For participants with 10% or fewer missing items on a given scale, the missing values were imputed using the person-mean imputation method (replacing the missing item with the mean of the respondent's completed items on that subscale).

Data collection tools

In this research, four questionnaires were used for data collection, including demographics, International Physical Activity Questionnaire (IPAQ), Ahvaz Hardiness Inventory (AHI), and Connor-Davidson Resilience Scale (CD-RISC).

Demographics included items such as hospital and ICU of employment, age (in years), gender (male/female), marital status (single/married/widowed or divorced), number of children, educational level (bachelor's/master's), work experience (in years), and Previous sports history (yes/no).

IPAQ– Short Form is a self-reported questionnaire that consists of 7 items assessing physical activity levels in individuals aged 15– 69 years. It collects information on household activities, gardening, work-related activities, transportation, leisure-time physical activities, and time spent sitting. Physical activity was assessed using the official International Physical Activity Questionnaire-Short Form (IPAQ-SF) scoring guidelines. Based on the standard IPAQ protocol, overall physical activity was calculated in MET-minutes per week and categorized into three distinct levels: (1) Low: <600 MET-min/week, indicating individuals who did not meet the criteria

for moderate or high activity levels; (2) Moderate: 600–2999 MET-min/week, achieved through ≥ 3 days of vigorous activity for at least 20 minutes/day ≥ 5 days of moderate-intensity activity or walking for at least 30 minutes/day, or any combination of walking, moderate-, or vigorous-intensity activities achieving at least 600 MET-min/week; and (3) High: ≥ 3000 MET-min/week, achieved through vigorous-intensity activity on at least 3 days achieving a minimum of 1500 MET-min/week, or 7 days of any combination achieving at least 3000 MET-min/week.¹⁸ The Persian version of the IPAQ has demonstrated acceptable reliability, with a Cronbach's alpha of 0.70 and a Spearman correlation coefficient of 0.90.¹⁹

CD-RISC is a 25-item scale that measures resilience on a 5-point Likert scale (0 = "not true at all" to 4 = "true all the time"). It assesses five dimensions includes personal competence/high standards (items 10, 11, 12, 16, 17, 23, 24, 25), trust in instincts (items 6, 7, 14, 15, 18, 19, 20), tolerance of negative effects (items 1, 2, 4, 5, 8), control (items 13, 21, 22), and spirituality (items 3, 9). Total scores range from 0 to 100, with higher scores reflecting greater resilience. In line with original scale scoring guidelines, resilience was analyzed primarily as a continuous variable. To provide contextual interpretation without arbitrary cutoff assignment, score ranges were categorized based on validated normative quartiles established in previous population-level literature (e.g., Low: 0–49, Moderate: 50–74, and High: 75–100; Citation). The reported classification of 'moderate resilience' reflects mean scores falling within the second and third quartiles of this established distribution. The Persian version has shown high reliability, with a Cronbach's alpha of 0.89.²⁰

AHI is a 27-item scale that measures psychological hardiness on a 4-point Likert scale (0 = "never" to 3 = "most of the time"). Items 6, 7, 10, 13, 17, and 21 are reverse-scored. Scores range from 0 to 81, with higher scores indicating greater hardiness. The scale has demonstrated good reliability, with a test-retest coefficient of 0.84 and a Cronbach's alpha of 0.76.²¹

Validity and Reliability

A single pilot study involving 30 ICU nurses (who were excluded from the main study) was conducted to evaluate the feasibility of the study procedures and assess the internal consistency of the instruments in the target population. Construct and content validity of the Persian versions of the questionnaires (IPAQ-SF, CD-RISC, and Hardiness Scale) had been rigorously established in previous validation studies in Iran¹⁸⁻²¹. In the present study, no new validity testing was performed; rather, only internal consistency reliability was re-evaluated in the current sample, yielding satisfactory Cronbach's alpha coefficients ($\alpha = 0.81$ for IPAQ-SF, $\alpha = 0.87$ for CD-RISC, and $\alpha = 0.84$ for Hardiness).

Data collection

The sampling was carried out over 3 months from January 2023 to the end of March. Data collection was conducted during morning, evening, and night shifts. The researcher visited the selected hospitals, met with the randomly selected nurses, and explained the study's objectives. The demographic questionnaire, the CD-RISC, the AHI, and the IPAQ were given to the nurses at the beginning of the shift and collected at the end of the shift after completion.

Data Analysis

Data were analyzed using IBM SPSS Statistics version 21. Missing data were managed using adjacent-item mean imputation. Descriptive statistics (frequency, percentage, mean, and standard deviation) were used to summarize the data. To maximize statistical power and preserve the full quantitative continuum of the measure, physical activity was primarily operationalized as a continuous variable (total MET-minutes/week) in bivariate correlation and multiple linear regression analyses. Furthermore, to examine group-level differences and enhance clinical interpretability, physical activity was also analyzed as a categorical variable (Low, Moderate, and High) in line with the official IPAQ scoring protocol using one-way ANOVA. This dual analytical approach allowed for both high-resolution continuous modeling of associations and standardized group-based comparisons.

The normality of continuous variables was assessed by examining the values of skewness and kurtosis, rather than relying on the Kolmogorov–Smirnov test, due to the relatively large sample size ($n = 225$). Normality of continuous variables was assessed using both numerical and graphical methods. Skewness and kurtosis indices were evaluated against established empirical thresholds, where values within ± 2.0 for skewness and ± 7.0 for kurtosis were considered indicative of an acceptable approximation to a normal distribution. Additionally, visual inspection of histograms and Normal Q–Q plots were conducted to confirm distributional symmetry and linearity prior to performing parametric statistical analyses.

To address the first research aim (determining the levels of physical activity, resilience, and hardiness), descriptive statistics and frequency distributions were used. To address the second aim (examining associations among variables), Bivariate association between physical activity, psychological resilience, and hardiness was evaluated using Pearson's correlation coefficient, utilizing continuous numerical scores for all three variables (total MET-minutes per week for physical activity, total CD-RISC score for resilience, and total hardiness score). For categorical comparisons, one-way Analysis of Variance (ANOVA) was conducted to compare continuous psychological scores across the physical activity categories (low, moderate, high). The Chi-square test of independence was used to examine relationships between categorical variables. The assumptions of the Chi-square test, particularly the expected cell frequencies (minimum expected count > 5 in at least 80% of cells), were systematically verified. In instances where cell counts were insufficient and assumptions were violated, Fisher's exact test (or Fisher–Freeman–Halton test for larger contingency tables) was applied.

Following statistically significant ANOVA outcomes, Tukey's Honest Significant Difference (HSD) post-hoc test was applied to perform pairwise group comparisons under the assumption of homogeneity of variances.

Homogeneity of variances was assessed using Levene's test, and the assumption was met for all comparisons ($P > 0.05$). Additionally, the chi-square (χ^2) test of independence was performed to examine the associations between categorical demographic/occupational characteristics and physical activity levels. Multiple linear regression analysis (enter method) was conducted to

evaluate the predictors of psychological resilience (dependent variable). Covariate selection for the multivariable linear regression models was guided by theoretical relevance from existing literature and preliminary bivariate analysis. Variables that demonstrated statistically significant bivariate associations ($P < 0.10$) with the outcomes or were established as clinical confounders in nursing literature (e.g., age, work experience, shift type, educational level) were included a priori. Categorical demographic predictors were converted into dummy variables, accounting for the 22 degrees of freedom in the final multivariable models.

Independent variables included hardiness and physical activity, which were entered as a continuous metric (total MET-minutes per week). Socio-demographic variables (e.g., age, work experience) were included as covariates based on their statistically significant bivariate associations with the dependent variable in preliminary analyses. Prior to regression modeling, core statistical assumptions were systematically evaluated: linearity was verified via scatterplots of standardized residuals against predicted values; independence of errors was confirmed using the Durbin–Watson statistic (acceptable range: 1.5–2.5); Multicollinearity was assessed using Variance Inflation Factors ($VIF < 3.0$) and Tolerance values (> 0.3); and homoscedasticity and normality of residuals were confirmed through visual inspection of residual plot diagrams and normal P–P plots.

A P value of < 0.05 was considered statistically significant.

Results

The study included 225 nurses, with a majority being female (78.2%), married (67.6%), and having a bachelor's degree (88%). The mean (SD) age of nurses was 35.23 (8.05) years (range: 23–53). The most common ICU department were cardiac surgery (24.9%) or general ICU (26.2%). 56.9% of nurses had work experience less than 10 years, with an average weekly work duration of 49.34 (8.9) hours. Rotating shifts were predominant (89.8%), and 50.2% of nurses reported no prior exercise history before entering nursing. Table 1 shows more details about other demographics.

Table 1. Demographics of ICU nurses, psychological resilience, and hardiness (n= 225)

Variable	N (%)	Resilience Mean (SD)	Indicators**	Hardiness Mean (SD)	Indicators**
Gender					
Male	49 (21.8)	64.36(10.56)	P= 0.012, t= -2.52	45.77(6.41)	P= 0.61, t= -0.42
Female	176 (78.2)	58.92(14)		46.36(9.06)	
Marital status					
Single	70 (31.1)	59.25(11.22)	P= 0.38*, F= 1.01	45.11(7.67)	P= 0.01*, F= 3.83
Married	152 (67.6)	60.24(14.25)		46.48(8.69)	
Divorced/ Widowed	3 (1.3)	63.50(24.74)		65(7.07)	
Education					
Bachelor's	198 (88)	59.62(13.81)	P= 0.14, t= -1.46	45.67(8.77)	P= 0.008, t= -2.69
Master	27 (12)	63.66(10.40)		50.33(5.09)	
Number of children					
1	68 (30.2)	57.94(15.04)	P= 0.21*, F= 1.54	45.64(10.22)	P= 0.49*, F= 0.71
2	43 (19.1)	62.37(16.25)		48.57(8.29)	
Non	114 (50.7)	60.54(11.13)		46.07(7.50)	
Working shift					
Fixed	23 (10.2)	59.13(15.63)	P= 0.71, t= -0.36	48.86(9.83)	P= 0.11, t= 1.56
Rotating	202 (89.8)	60.21(13.27)		45.93(8.36)	
Hospital					
Shohada	14 (6.2)	60.64(9.09)	P= 0.04*, F= 2.55	49.42(7.59)	P= 0.03*, F= 2.58
Madani	85 (37.8)	62.98(13.91)		46.48(8.91)	
Emam Reza	48 (21.3)	57.33(14.29)		43.06(8.96)	
Sina	62 (27.6)	57.22(11.23)		47.19(6.96)	
Talegani	16 (7.1)	63.81(17.06)		46.23(9.90)	
Previous sports history					
Yes	112 (49.8)	62.67(13.88)	P= 0.004, t= 2.89	47.75(8.33)	P= 0.007, t= 2.69
No	113 (50.2)	57.55(12.66)		44.72(8.52)	

N: Number, SD: Standard deviation, *One-way analysis of variance, **Independent samples t-tests.

Physical activity levels were classified using MET-minutes/week (Table 2). The mean psychological resilience score was 60.10 (13.50) (range: 24–92), and hardiness averaged 46.23 (8.54) (range: 24–70). Results of Pearson's correlation test showed a significant positive correlation between these two variables ($r= 0.53$, $P< 0.001$). No significant association was found between physical activity levels and resilience or hardiness ($P> 0.05$).

Table 2. Associations between physical activity levels with psychological resilience and hardiness

Physical activity level	N (%)	Mean(SD)	
		Resilience	Hardiness
Low activity	102 (45.3)	58.78(13.45)	46.20(9.18)
Moderate activity	35 (15.6)	60.22(12.92)	47.74(8.32)
Increased activity	43 (19.1)	61.44(14.32)	45.41(8.60)
High activity	45 (20)	61.73(13.37)	45.91(7.18)
ANOVA*	---	P= 0.56, F= 0.68	P= 0.67, F= 0.51

*One-way analysis of variance, N: Number, SD: standard deviation.

The results of the statistical analysis indicated that there is a statistically significant association only between physical activity levels and gender ($P < 0.05$). For variables with small cell counts where Chi-square assumptions were violated, Fisher's exact test was reported. Table 3 shows more details about associations between physical activity levels with demographics.

Table 3. Associations between physical activity levels with demographics

Variable	Physical activity level N				P value ^j
	Low activity	Moderate activity	Increased activity	Intense activity	
Gender					
Male	14	11	9	15	0.02
Female	88	24	34	30	
Marital status					
Single	27	11	14	18	0.43
Married/Divorced/ Widowed	75	24	29	27	
Education					
Bachelor's	95	31	36	36	0.11
Master	7	4	7	9	
Number of children					
1	31	12	13	12	0.24
2	26	6	7	4	
Non	45	17	23	29	
Working shift					
Fixed	13	2	5	3	0.53
Rotating	89	33	38	42	
Hospital					
Shohada	5	4	2	3	0.84
Madani	39	14	13	19	
Emam Reza	23	5	12	8	
Sina	29	8	12	13	
Talegani	6	4	4	2	
Previous sports history					
Yes	47	16	21	28	0.30
No	55	19	22	17	

^jchi-squared test, N: Number.

Pearson correlation analyses identified significant positive associations between demographic/professional variables and psychological outcomes among nurses. Age exhibited statistically significant correlations with both resilience ($r = 0.14$, $P < 0.05$) and psychological hardiness ($r = 0.15$, $P < 0.05$). Weekly working hours demonstrated stronger differential associations, showing a marked correlation with resilience ($r = 0.37$, $P < 0.05$) and a moderate correlation with hardiness ($r = 0.54$, $P < 0.05$). Table 1 shows more details related to parametric group comparisons via independent samples *t*-tests and ANOVA between demographic variables and psychological outcomes. Additionally, to determine the independent contribution of each variable while controlling for others, multiple linear regression was performed. (Table 4).

Table 4. Multiple linear regression analysis: Adjusted associations of demographic, occupational, and physical activity variables with resilience and hardiness among ICU nurses (n=225)

Variable	Resilience (CD-RISC)			Hardiness (AHI)		
	B (95% CI)	β	P value	B (95% CI)	β	P value
Physical Activity (PA) Level (Ref: Low)						
Moderate	1.89 (-2.72, 6.50)	0.058	0.420	0.89 (-2.17, 3.95)	0.041	0.569
Increased	2.45 (-1.83, 6.73)	0.074	0.260	-1.23 (-4.14, 1.68)	-0.058	0.407
Intense	2.78 (-1.57, 7.13)	0.083	0.209	-0.67 (-3.52, 2.18)	-0.031	0.646
Previous Sports History (Ref: No)						
Yes	6.84 (2.76, 10.92)	0.251	0.001	4.78 (1.60, 7.96)	0.215	0.003
Age (per 1-year increase)						
Continuous	0.189 (0.018, 0.360)	0.142	0.032	0.089 (-0.023, 0.201)	0.101	0.117
Gender (Ref: Male)						
Female	-4.52 (-8.00, -1.04)	-0.169	0.011	-1.23 (-3.43, 0.97)	-0.071	0.273
Education (Ref: Bachelor)						
Master	3.12 (-0.70, 6.94)	0.104	0.109	4.12 (1.04, 7.20)	0.182	0.009
Marital Status (Ref: Single)						
Married	1.23 (-1.87, 4.33)	0.053	0.438	1.45 (-0.33, 3.23)	0.096	0.112
Divorced/Widowed	2.89 (-3.26, 9.04)	0.062	0.355	5.67 (0.98, 10.36)	0.169	0.018
Weekly Working Hours (per 1-hour increase)						
Continuous	0.244 (0.079, 0.409)	0.198	0.004	0.124 (0.014, 0.234)	0.152	0.028
Hospital Affiliation (Ref: Shohada)						
Madani	-1.56 (-7.21, 4.09)	-0.041	0.588	-2.34 (-5.99, 1.31)	-0.089	0.216
Emam Reza	-6.31 (-10.92, -1.70)	-0.195	0.008	-3.89 (-7.47, -0.31)	-0.153	0.034
Sina	-5.89 (-10.58, -1.20)	-0.182	0.014	-1.98 (-5.49, 1.53)	-0.078	0.269
Talegani	2.14 (-4.88, 9.16)	0.042	0.548	-1.12 (-6.12, 3.88)	-0.031	0.661

Note: CI = Confidence Interval; B = Unstandardized Regression Coefficient; β = Standardized Regression Coefficient. Models were adjusted for work experience, shift pattern, number of children, and other demographic variables (none were significant, data not shown in table for brevity). Statistically significant predictors ($P < 0.05$) are highlighted in bold. Model for Resilience: Adjusted $R^2 = 0.234$, $F(22, 202) = 4.87$, $P < 0.001$. Model for Hardiness: Adjusted $R^2 = 0.187$, $F(22, 202) = 3.92$, $P < 0.001$. $df = 22$ reflects the total number of continuous predictors and dummy-coded categories of demographic and occupational covariates adjusted in the final model.

The Variance Inflation Factor (VIF) values for all variables in the regression models ranged from 1.08 to 2.34, indicating no evidence of multicollinearity (all $VIF < 5$). The regression models were statistically significant for both resilience (Adj. $R^2 = 0.234$, $F = 4.87$, $P < 0.001$) and hardiness (Adj. $R^2 = 0.187$, $F = 3.92$, $P < 0.001$). In line with the bivariate findings, current physical activity levels (moderate, increased, or intense) were not independently associated with either resilience or hardiness (all $P > 0.05$). However, a previous history of regular sports participation was most strongly associated with both resilience ($B = 6.84$, 95% CI: 2.76 to 10.92, $P = 0.001$) and hardiness ($B = 4.78$, 95% CI: 1.60 to 7.96, $P = 0.003$). Among demographic variables, age ($B = 0.189$, $P = 0.032$), female gender ($B = -4.52$, $P = 0.011$), and weekly working hours ($B = 0.244$, $P = 0.004$) were significantly associated with resilience, while master's education ($B = 4.12$, $P = 0.009$), being divorced/widowed ($B = 5.67$, $P = 0.018$), and weekly working hours ($B = 0.124$, $P = 0.028$) were significant for hardiness. Notably, hospital affiliation exhibited outcome-specific variations. In the

adjusted model, nurses at both Emam Reza and Sina hospitals reported significantly lower resilience scores compared to the reference hospital (Shohada Hospital). However, for psychological hardiness, a statistically significant reduction was observed exclusively among nurses at Emam Reza Hospital, whereas no significant difference was found for Sina Hospital relative to the reference.

Discussion

This cross-sectional study examined physical activity levels and their association with psychological resilience and hardiness among 225 ICU nurses in Iran. The main findings were threefold. First, the majority of participants reported low physical activity levels, with only 20% classified into the intense physical activity category. Second, resilience and hardiness scores were within the moderate-to-high range, and the two constructs were moderately correlated ($r = 0.53$). Third, no statistically significant association was found between current physical activity level and either resilience or hardiness. However, a previous sports history prior to employment was consistently associated with higher scores on both psychological measures in both bivariate and adjusted regression analyses.

The finding that 45.3% of ICU nurses reported low physical activity is consistent with previous research among Iranian healthcare workers, which has documented insufficient engagement in leisure-time physical activity.^{19,22} This pattern may be explained by several occupational characteristics inherent to ICU nursing: long shifts (average 49.34 hours/week in this sample), rotating schedules (89.8%), and heavy physical workloads during shifts. These factors may reduce the time, energy, and motivation available for structured exercise outside work hours. Notably, the physically demanding nature of ICU work which involves substantial standing and walking, does not appear to translate into sufficient leisure-time physical activity, supporting the distinction between occupational physical demands and intentional exercise.^{8,23} This distinction has important implications for health-promotion interventions, suggesting that workplace wellness programs should focus not only on reducing occupational fatigue but also on facilitating access to structured physical activity.

Despite low physical activity, participants demonstrated resilience and hardiness scores comparable to or higher than those reported in several international studies. The mean resilience score (60.10) was similar to that reported in Australian nurses and higher than in Singaporean nurses,¹⁴⁻²⁴ although lower than in Greek nurses.¹³ This variation likely reflects differences in measurement instruments, sample characteristics, and healthcare system contexts.

The moderate-to-high resilience observed in this sample may reflect the adaptive capacities that ICU nurses develop through repeated exposure to high-pressure clinical environments. Critical care settings demand rapid decision-making, emotional regulation, and sustained attention-experiences that may foster psychological resources over time.¹⁵⁻¹⁶ The mean hardiness score observed in this study (46.23) aligns with previous investigations among Iranian healthcare professionals, reinforcing hardiness as a crucial personality resistance resource in high-stress clinical environments. Psychological hardiness comprising commitment, control, and challenge

functions as a cognitive-evaluative buffer that transforms potential stressors into opportunities for personal growth. Our findings demonstrate a significant positive association between hardiness, resilience, and physical activity levels. This mechanism suggests that hardy nurses are more likely to adopt proactive coping strategies, including regular physical exercise, which in turn mitigates occupational burnout and enhances resilience. Physical activity may serve as both a behavioral manifestation of hardiness (reflecting commitment to health and active control over lifestyle) and a physiological foundation that reinforces hardiness components under chronic workplace stress.²⁵⁻²⁷

The moderate positive correlation between resilience and hardiness suggests that these two constructs, while conceptually distinct, are closely linked adaptive resources. Hardiness- characterized by commitment, control, and challenge- may enable nurses to appraise stressful situations as manageable rather than threatening.⁹⁻¹⁰ Resilience- defined as the capacity to recover from adversity- may then facilitate effective coping once stress is encountered.^{11,15} This complementary relationship has practical implications: interventions that strengthen one resource may potentially bolster the other. For example, hardiness training programs that enhance perceived control may indirectly improve resilience by reducing the emotional toll of workplace stressors.¹⁴

The absence of a statistically significant relationship between current physical activity level and resilience or hardiness is the most notable finding of this study and warrants careful interpretation. Several explanations may account for this result. First, while domain-specific physical activity was not evaluated separately in this study, it is plausible that a portion of the reported physical activity may reflect occupational movement during demanding clinical shifts rather than structured leisure-time exercise.

The IPAQ captures all physical activity, including work-related movement, but the psychological benefits of physical activity are primarily associated with voluntary exercise performed for health or enjoyment, rather than obligatory activity under conditions of fatigue and time pressure. This distinction is supported by previous research showing that leisure-time physical activity, but not occupational physical activity, is associated with improved mental health outcomes.^{10,28}

Second, the cross-sectional design may obscure time-lagged effects. Current physical activity levels may not reflect lifetime patterns of exercise engagement. In this study, participants with a history of sports participation prior to employment demonstrated higher resilience and hardiness, suggesting that the duration and consistency of exercise engagement may matter more than current activity levels. Third, measurement limitations may have attenuated the association. Self-reported physical activity is subject to recall bias and social desirability bias, particularly in a cultural context where physical activity may be socially valued. The use of objective activity monitors in future research could provide more precise estimates.^{10,29}

In comparison with previous studies, the lack of association between physical activity and resilience in this study contrasts with some previous research, including a study by Yu and colleagues that reported a positive relationship between objectively measured physical activity and resilience in ICU nurses.¹⁰ Several factors may explain this discrepancy. First, they used

accelerometers to measure physical activity, whereas the present study used self-reported IPAQ. Objective measurements are less susceptible to recall bias and may capture activity patterns more accurately. Second, the present study's sample comprised exclusively ICU nurses in Iran, whereas previous studies have included nurses from various settings and countries. Cultural, occupational, and systemic differences may moderate the relationship between physical activity and psychological outcomes.²⁸⁻²⁹ Third, Yu and colleagues measured resilience using a different version of the CD-RISC,¹⁰ which may limit comparability.

The finding that pre-employment sports history was associated with higher resilience and hardiness-even after adjusting for demographic and occupational variables-is noteworthy. This association may reflect several mechanisms. Early or sustained engagement in organized sports may foster psychological skills such as goal-setting, perseverance, stress tolerance, and teamwork skills that are transferable to the high-stress ICU environment.¹⁰ Alternatively, the association may reflect a selection effect, whereby individuals with greater inherent psychological resources are more likely to engage in sports. The cross-sectional design does not allow disentangling these possibilities. Nevertheless, this finding has practical implications. It suggests that interventions aimed at promoting physical activity among nursing students or early-career nurses may yield long-term benefits for psychological adaptation. However, this interpretation should be considered exploratory and requires confirmation through longitudinal research.

Several demographic and occupational variables were independently associated with resilience and hardiness in the regression models. Female gender was associated with lower adjusted resilience scores, a finding that warrants careful interpretation. Because potential mediating factors such as subjective stress exposure, coping mechanisms, and socio-cultural role expectations were not directly evaluated in this study, these proposed mechanisms remain hypothetical explanations rather than empirically established findings. However, previous literature in Iranian healthcare settings suggests that female nurses often face dual-role burdens (balancing demanding clinical shifts with domestic caregiving responsibilities) and different socio-cultural stressors, which may indirectly influence psychological resilience.³⁰⁻³³ This may reflect gender-based differences in occupational stress exposure, coping styles, or cultural expectations. Alternatively, it may be an artifact of the sample composition (78.2% female) and should be interpreted cautiously. Weekly working hours were positively associated with both resilience and hardiness, a counterintuitive finding given that longer working hours are typically associated with burnout and reduced well-being.^{1-2,5-6} One possible explanation is reverse causation. More resilient nurses may be better able to handle longer shifts and may therefore be assigned to or request more hours. Another possibility is that this association reflects contextual factors, such as the availability of organizational support or workload distribution in specific hospitals.

Notably, hospital affiliation showed significant variation in resilience scores, with Emam Reza and Sina hospitals reporting lower scores than the reference hospital (Shohada), even after adjusting for individual characteristics. Because organizational metrics such as managerial support, institutional culture, workload distribution, and resource availability were not directly measured in the present study, these unmeasured systemic factors are proposed as potential

hypotheses that may account for inter-hospital disparities, rather than confirmed determinants. This suggests that organizational culture, management support, workload distribution, and resource availability may be critical determinants of nurses' psychological well-being.^{11,15-16} These findings highlight the importance of institutional-level interventions alongside individual-level support.

This study limitations include reliance on self-reported data and a region-specific sample, which may limit generalizability. Because the questionnaires used in this study relied on self-reported responses, the results may be affected by recall bias and social desirability bias, particularly in reporting physical activity behaviors. Although an appropriate instrument was used for measurement in this study, the possibility of measurement error cannot be ignored. Additionally, questionnaires were completed during work shifts, which may have influenced responses due to fatigue or time pressure. This potential source of response bias should be considered when interpreting the findings. Furthermore, the cross-sectional design of this study limits the ability to infer causal relationships between physical activity, resilience, and psychological hardiness. The observed associations represent correlations at a single point in time and should not be interpreted as evidence of cause-and-effect relationships. Longitudinal studies are needed to clarify the temporal and causal relationships among physical activity, resilience, and hardiness.^{10,14} Objective measurement of physical activity using accelerometers, and qualitative research to understand nurses' perceptions of exercise and psychological adaptation, would also be valuable.²⁹ Additionally, intervention studies that test the effects of structured exercise programs on psychological outcomes in ICU nurses would provide the strongest evidence for practice.¹⁰ Finally, measurement biases inherent to self-reported data and study procedures should be considered. Physical activity was assessed using the self-reported IPAQ-SF, which is subject to recall and social desirability biases that often lead to the overestimation of actual physical activity levels compared to objective measures (e.g., accelerometry). Furthermore, questionnaires were distributed at the beginning and collected at the end of intensive care unit shifts. The acute physical and mental fatigue accumulated over demanding shifts, combined with variations in shift timing (day vs. night shifts), and may have influenced participants' recall precision and subjective psychological appraisals. These measurement artifacts could have attenuated or artificially inflated the observed associations between physical activity, hardiness, and resilience.

This study has several strengths. The use of validated instruments, random sampling, and adjusted regression analyses enhances the robustness of the findings. The simultaneous examination of physical activity, resilience, and hardiness in a homogeneous sample of ICU nurses provides a novel contribution to the literature.^{14,16} From a practical perspective, the findings suggest that healthcare organizations should adopt a multifaceted approach to supporting ICU nurses' well-being. First, interventions should facilitate access to structured physical activity by addressing barriers such as shift schedules, workload, and lack of on-site facilities. Second, psychological support programs that foster resilience and hardiness such as mindfulness training, cognitive-behavioral stress management, and peer support groups should be integrated into nursing education and professional development.²⁶⁻²⁷ Third, organizational improvements, including

adequate staffing, supportive supervision, and manageable workloads, are essential for creating conditions that enable nurses to thrive.^{11,15}

Conclusion

This study highlights two critical findings: (1) ICU nurses in Iran exhibit insufficient physical activity levels but moderate-to-high resilience and hardiness, and (2) while no direct statistical link exists between physical activity and psychological traits, nurses with pre-employment sports backgrounds demonstrate superior resilience and hardiness. The strong correlation between resilience and hardiness reinforces their complementary roles in mitigating occupational stress. In conclusion, while healthcare institutions may consider facilitating opportunities for structured physical activity to address the high prevalence of physical inactivity and support overall occupational health among ICU nurses, it should be noted that the present study did not establish a direct association between current physical activity and resilience or hardiness. Instead, targeted institutional strategies focusing on organizational support and workload management remain essential for bolstering psychological well-being.

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Conflict of Interest

The authors stipulate that there is no conflict of interest in the present study.

Data Accessibility

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Ethical Approval

Ethics approval was obtained from the Research Ethics Committee of Tabriz University of Medical Sciences (Code: IR.TBZMED. REC.1402.948).

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Research Highlights
What is the current knowledge? • Insufficient physical activity is common among nurses and may have significant implications for their physical and psychological well-being. • Resilience and psychological hardiness are critical coping resources for healthcare professionals in high-stress environments; however, their relationship with physical activity patterns among ICU nurses remains insufficiently understood. What is new here? • Nearly half of the ICU nurses in this study reported low levels of physical activity, despite demonstrating moderate-to-high levels of resilience and hardiness. • Current physical activity levels were not significantly associated with resilience or hardiness among ICU nurses. • A history of sports participation prior to entering the nursing profession was associated with significantly higher resilience and hardiness scores. • Resilience and psychological hardiness showed a moderate positive correlation ($r = 0.53$, $P < 0.001$), indicating that these psychological resources act complementarily among ICU nurses.

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