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Flexibility and body composition: An analysis of sit-and-reach performance and body mass index in first-year undergraduate students

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ABSTRACT

Flexibility and body composition are important components of physical fitness and play a key role in health promotion and disease prevention. As sedentary lifestyles increase worldwide, it is important to assess health indicators in different populations, particularly in the Philippines, where the prevalence of overweight and obesity is rising. This study examined the relationship between flexibility and body composition using the sit-and-reach test and body mass index (BMI). A cross-sectional observational design was applied to 130 first-year undergraduate students at Nueva Ecija University of Science and Technology in the Philippines. Data on age, height, weight, and BMI were collected, and flexibility was assessed using the sit-and-reach test. Descriptive statistics, Pearson correlation analysis, and t-tests were used for data analysis. The results showed sex-based differences in demographic and body composition characteristics, with males generally having higher BMI values and females showing a higher prevalence of underweight. Although flexibility scores varied widely among participants, no statistically significant relationship was found between flexibility and sex, age, or BMI. These findings highlight the complex nature of flexibility and suggest that future studies should consider lifestyle factors, levels of physical activity, and genetic influences when designing health interventions for university students.

1. Introduction

Physical fitness is a compound term with diverse elements, including cardiorespiratory endurance, muscular strength, muscular endurance, flexibility, and body composition. All of them are crucial elements of the preservation of overall health, the prevention of chronic diseases (Stefani and Galanti, 2017), and increasing the quality of life (Gavilán-Carrera et al., 2019). The complex correlation between the elements of physical fitness, especially body composition and flexibility, has been of great concern as far as the discourse of health on a global scale is concerned. The current rising trend in sedentary living and its subsequent increase in non-communicable diseases (NCD) in the world calls for a holistic evaluation of health marker measures even among healthy groups or individuals, such as university students (Katzmarzyk et al., 2022; WHO, 2024). Along with a high possibility of developing musculoskeletal disorders, flexible activity decreases functional capacity, which is frequently a result of inactivity. At the same time, unhealthy body composition with excessive adiposity is a well-known determinant of increased risk of chronic illness, including cardiovascular disease, type 2 diabetes, and some cancers (El-Alameey et al., 2023). It is paramount to investigate how these factors interact in young adults starting college education, as this phase of life can be a turning point towards more autonomous lifestyles that tend to affect long-term health patterns tremendously (Mahindru et al., 2023).

The issues of physical inactivity and the associated health implications are rather urgent in the Philippine setting. According to the National Nutrition Council, though there might be no national research data stating the flexibility and body type of first-year undergraduate students, the more exhaustive surveys of body types of Filipino youngsters and adults demonstrate the undeniable increase in the obesity and overweight levels. This trend is due to the cultural tendency towards sedentary recreation and the usage of more

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processed food. This demonstrates an absolute necessity in measuring defective health levels in young adults, specifically those beginning their university experience in life, because this segment of the population constitutes the real workforce and an important area of focus of health promotion measures. These may be useful in understanding the present health situation of Filipino youth and determining interventions.

Flexibility, which can be tested by a sit-and-reach test among other exercises, is a significant part of physical fitness that defines how well a person is. This level of flexibility enables free movement of the joints, avoiding injuries, balancing the body in standing postures, and performing better sports and activities of daily living. Conversely, lacking flexibility may cause the muscles to get stiff and sore and develop a sensitivity to injuries, especially in the lower back and hamstrings. Among young adults, high flexibility is needed both in the short term to ensure physical comfort and in the long term to develop a healthy movement environment that will help offset age-related mobility losses and can serve as a preventative measure against musculoskeletal disorders in the future (Latorre Román et al., 2018).

In addition to flexibility, an individual's body composition, which is usually determined by Body Mass Index (BMI), can give invaluable ideas concerning a person's health state. According to the National Institute of Health, although BMI is limited, it is a well-known and simple screening process that defines oneself as underweight, normal weight, overweight, or obese. An optimal body composition, i.e., an optimal proportion between lean muscle tissue and body fat, is the prerequisite to better physiological functioning. Unwanted body fat, especially visceral fat, and metabolic dysfunction are highly linked with the prevalence of inflammation and increased risk of chronic disorders (Goossens, 2017). Thus, the body composition among young adults will create a baseline experience of metabolic health and any future health risks.

Although it is universally acknowledged that flexibility and body composition are vital, the concrete research gap relates to a close study of the relationship between the two aspects in particular groups of people, primarily first-year undergraduate students. Although these parameters can be looked at separately in individual studies, limited studies simultaneously look at both flexibilities, through the sit-and-reach test, and body composition, through BMI, during this critical transitional stage in life, that is, early adulthood. In addition to the above, a direct comparison analysis of these metrics on a global scale and comparison with specific local environments, like the Philippine case under study, has not been fully established. Such a gap constrains the comprehensive picture of the health condition of this group of people and the development of customized health promotion interventions.

This study is an attempt to ensure that this need is filled and therefore proposes as its primary aim a study of flexibility, measured through the sit-and-reach experiment, and body composition, measured through BMI, among first-year undergraduate students. In particular, to (1) identify the status of body composition through the calculation of their Body Mass Index (BMI); (2) evaluate existing hamstring flexibility levels and lower back flexibility levels of a group of first year undergraduate students through the standardized sit-and-reach test protocol; (3) compare the results of flexibility test scores and Body Mass Index (BMI) ratings to analyze the possible correlation between these two health attributes in the body; (4) explore possible sex-specific differences in flexibility and body composition, as well as the connection between the two aspects of health; and (5) add to the knowledge in physical health characteristics of first-year university students, which could also be used as a starting point of a longitudinal research or intervention in the future.

The data can be used to build specific health interventions, physical activity programs, and wellness programs to address the unique needs of first-year university students, specifically in your community and perhaps even worldwide. Finally, an improved knowledge of the flexibility and body composition profile of this group may help to promote healthier lifestyles and the well-being of the future leaders and citizens.

2. Materials and methods

The study used a cross-sectional observational research design. The method is appropriate for measuring the prevalence of characteristics (flexibility and body composition) in a specified population (first-year students of the undergraduate level) at one specific time and investigating the relationship between the mentioned variables. Although a cross-sectional design does not allow for the establishment of causality, it can find correlations and come up with subsequent longitudinal or interventional studies (Wang and Cheng, 2020), which is highly applicable due to the changing dynamics of this demographic in their first year.

The research study involved 130 first-year undergraduate students enrolled at Nueva Ecija University of Science and Technology-San Isidro campus, in the Philippines, in the first semester of the academic year 2024-2025. The participants were recruited by being oriented on Physical Activity towards Health and Fitness subject with the permission of the faculty and administrative officials. It was focused on voluntary participation and the right to withdraw from the study. Those who had pre-existing injury or conditions of musculoskeletal injuries or preconditions that could not allow them to engage in safe and precise execution of the V sit-and-reach test, those whose medical conditions could have a substantial impact on body composition or limberness, those who refused to give informed consent, and pregnant women did not meet the selection criteria. The general health status of all

participants was determined using the Physical Activity Readiness Questionnaire (PAR-Q). This general health awareness was tested in this questionnaire. It evaluates the exposure to potential sources of risk in moderate exertion and follows up on the family history and the intensity of the disease. If a subject demonstrates the features of cardiovascular disease and belongs to the high-risk group, then the subject is excluded from the study.

There were two sections of the demographic questionnaire. The age and sex of the participants represented the first section. Researchers also measured variables like weight, height, and the body mass index (BMI) in the second part of the questionnaire, noting the information from them. A calibrated stadiometer measured standard height, and a digital scale measured body weight, which we recorded up to 0.1 kg. Body composition was determined by computing Body Mass Index (BMI), which is body mass index = weight (kg) / height (m^2). The BMI was assessed according to the following categories and is termed underweight (< 18.5), normal weight (18.5-24.9), overweight (25.0-29.9), obese class I (30.0-34.9), obese class II (35.0-39.9), and obese class III (> 40.0) (Table 1). Hamstrings and lower back flexibility were measured using the sit-and-reach test because of its wide application, ease of administration, low cost, and moderate validity when measuring hamstring extensibility, as stated in the guidelines by the American College of Sports Medicine (ACSM). First, lay down a baseline on the floor. Then, place the ruler across the line, aligning the 15-inch mark with the baseline point. The participant is seated on the ground at the heels of the baseline, and the feet are 12 inches apart. During the test, the legs should be straight. Gradually, one leans forward as far as one can along the ruler. Have participants maintain the extreme point achieved for 2 seconds; then, measure the distance. Administer the test thrice and record the highest scores. Tables 2 and 3 present the male and female standards and performance ratings for the sit-and-reach test.

Table 1: WHO BMI classification (WHO, 2024)

Classification	BMI (kg/m^2)	Risk of comorbidities
Underweight	< 18.5	Low
Normal weight	18.5-24.9	Average
Overweight	25.0-29.9	Mildly increased
Obese class I	30.0-34.9	Moderate
Obese class II	35.0-39.9	Severe
Obese class III	≥ 40.0	Very severe

Table 2: Male norms and performance rating for the sit-and-reach test

Performance rating	Men	
	Age < 35 years	Age 26-49 years
Excellent	> 17.9	> 16.1
Good	17.0 – 17.9	14.6–16.1
Average	15.8 – 17.0	13.9–14.6
Fair	15.0 – 15.8	13.4–13.9
Poor	< 15.0	< 13.4

The researchers analyzed the data using the Statistical Package for the Social Sciences (SPSS) software version 20. To analyze the participants' demographic characteristics, the sit-and-reach flexibility test and BMI distribution, descriptive statistics, namely the frequency, percentage, mean, and standard deviation, were utilized. The strengths and directions of the linear relationship between the demographic profile, sit-and-reach scores, and Researchers calculated and determined BMI with the Pearson product-moment correlation coefficient at a $p < 0.05$ significance level. Independent samples t-tests compared the means of the sit-and-reach scores and BMI values between the various subgroups, especially the sexes, to establish any significant deviations.

Table 3: Female norms and performance rating for the sit-and-reach test

Performance rating	Women	
	Age < 35 years	Age 26-49 years
Excellent	> 17.9	> 17.4
Good	16.7 – 17.9	16.2 – 17.4
Average	16.2 – 16.7	15.2 – 16.2
Fair	15.8 – 16.2	14.5 – 15.2
Poor	< 15.4	< 14.5

3. Results and discussion

3.1. Demographic profile of the study population

Table 4 presents the mean and standard deviation of male and female first-year undergraduates' age, weight, height, and Body Mass Index (BMI). The average age of the male participants is 19.0 years, and that of the female participants is 18.47 years, less than that of their male counterparts. The standard deviation of age among the females is lower than the standard deviation of the males (0.99 as opposed to 1.98), implying that the age of the female participants has a greater tendency to be close to its mean, which indicates that there is less variability in age among the female sample. The average weight of male students is 62.26 lower than that of female students, which is 49.46 kg. The standard deviation of the weight of males (15.03 kg) is significantly higher than that of females (8.97 kg), so the weight distribution of male subjects is notably wider or more variable. Male students are taller, with a mean height of 1.69 meters. The average height of female students is 1.57 inches. Both groups have relatively small standard deviations regarding height (0.06 and 0.07 standard deviations in males and females, respectively), indicating that heights within the same gender category are similar and near the mean values of heights. Male students' BMI is 21.69 kg/m^2, with the average value, while the mean BMI of female students is slightly lower (19.97 kg/m^2) but still within the range of expected values. As it has been in weight, the standard deviation of BMI values is greater in the male (4.94) than in the female (3.69) cohort, reflecting greater dispersion in BMI of the male subjects. Normal age and anthropometric features characterize the demographic picture of first-year undergraduate students, where one can identify sex differences. Males were somewhat older

than the females, whose ages were less variable, as is the case at regular universities, starting ages. Additionally, males were heavier and taller than females, and individuals had more weight heterogeneity according to established biological sexual dimorphism (Jacinto et al., 2024). The average BMI of the two sexes was within the healthy range, but on average, males were above females in their BMI, and BMI values did not vary as much with females as they did with males.

The trend in which men possess more diverse body compositions with higher mastication in underweight/obesity, and females, in some cases, display an elevated prevalence of underweight, is in line with previous findings in the university population (Alkazemi, 2019).

Table 4: Demographic profile of the study population (n = 130)

Variables	Male (n = 50)	Female (n = 80)
Age	19.0 ± 1.98	18.47 ± 0.99
Weight (kg)	62.26 ± 15.03	49.46 ± 8.97
Height (m)	1.69 ± 0.06	1.57 ± 0.07
BMI (kg/m^2)	21.69 ± 4.94	19.97 ± 3.69

Mean ± standard deviation (SD)

3.2. Anthropometric characteristics: Body mass index (BMI)

As shown in Table 5, the anthropometric data of the first-year undergraduate students, namely the Body Mass Index (BMI) distribution of the students participating in the present study, indicate a different pattern in men (n = 50) and women (n = 80) participants. The number of participants in the "Normal Weight" (BMI 18.5-24.9 kg/m^2) category entails a low risk of comorbidities, making a considerable fraction of the total sample fall in this category. Notably, a normal BMI characterizes 52.0% (n = 26) of males and 48.8% (n = 39) of female students. Interestingly, a bigger proportion of the female students are in the Underweight category (BMI < 18.5 kg/m^2), and this proportion stands at 41.3 (n = 33) compared to that of 28.0 (n = 14) male students. On the other hand, male students showed a greater prevalence in the upper BMI values. 14.0% (n = 7) of the males are categorized as Overweight (BMI 25.0 – 29.9 kg/m^2), where comorbidities are moderately elevated, in contrast to 7.5% (n = 6) of the females. Moreover, the number of male students under the category of Obese Class I (BMI 30.034.9 kg/m^2) is 6.0% (n = 3), which is quite concerning since males are at moderate risk of comorbidity, and only 2.5% (n = 2) of female students fall in the same category. There was a high percentage of people of both genders with normal BMI, signifying that they were not overweight; they all differed at the ends, where there was a high percentage of people with low BMI and high BMI, respectively. The rate of females with the Underweight category was higher than that of males, an observation that is supported by current literature that has mainly concluded an increased prevalence of low BMI among female university students (Kuan et al., 2011). On the other hand, the category of male students was more prevalent in the two categories of Overweight and Obese Class I.

It is in line with the overall studies that males in the same age group might be more likely to belong to higher classes of BMI and moderate health risk. Moreover, knowing such distributions is vital when identifying possible health risks and guiding specific health activities among university populations (Saintila et al., 2024)

Table 5: Anthropometric characteristics: Body mass index (BMI)

BMI (kg/m^2)	Male n (%)	Female n (%)	Risk of comorbidities
Underweight (< 18.5)	14 (28.0)	33 (41.3)	Low
Normal weight (18.5-24.9)	26 (52.0)	39 (48.8)	Average
Overweight (25.0-29.9)	7 (14.0)	6 (7.5)	Mildly increased
Obese class I (30.0-34.9)	3 (6.0)	2 (2.5)	Moderate
Total	50	80	

3.3. Flexibility assessment: Sit-and-reach test scores of first-year undergraduate students

Table 6 indicates that the levels of flexibility in first-year undergraduate students, as measured by the standardized sit-and-reach test, have different performance distributions between male (n = 50) and female (n = 80) subjects. In the male group, the highest percentage, 48.0 percent (n = 24), attained an "Excellent" performance rating (scores > 17.9 cm), which connotes high flexibility of the hamstring and lower back. Subsequently, 10.0% (n = 5) was classified as Good (17.017.9 cm), and 8.0% (n = 4) was moderate or average (15.817.0 cm). A significant fraction, 28.0 per cent (n = 14), possessed a flex back of Poor (scores < 15.0 cm), and 6.0 per cent (n = 3) were rated Fair (15.0-15.8 cm). The highest number of females who also obtained an excellent score (42.5 percent, n = 34), with scores greater than 17.9 cm, indicates high levels of flexibility among females in this population sample. On the other hand, a large percentage of the female students, 41.3 % (n = 33), have had a score of poor flexibility (< 15.4 cm). Female students had smaller percentages of being categorized as "Average" (5.0%, n = 4), "Good" (3.8%, n = 3), and "Fair" (7.5%, n = 6).

The standardized sit-and-reach test analysis showed that male students mainly exhibited superior hamstring and lower back flexibility, with a good percentage recording the highest performance score. Nevertheless, a significant group of males was also poor in flexibility. Many female students also experienced and most likely attained excellent flexibility, suggesting a high percentage of flexibility among them. In contrast, a relatively high proportion of females were labelled as having poor flexibility,

implying a bimodal distribution with many being very flexible, but a significant portion of females having poor flexibility. The findings often pointing at complex gender-based variances in flexibility, with some suggesting that the overall flexibility in females may be higher because of physiological aspects, whereas others hold that for both sexes, there is considerable variance. Diverse physical activity levels, lifestyles, and anatomy may determine such divergent flexibility profiles.

Table 6: Flexibility assessment: Sit-and-reach test scores of first-year undergraduate students

Performance rating	Male n (%)	Female n (%)
Excellent	24 (48.0)	34 (42.5)
Good	5 (10.0)	3 (3.8)
Average	4 (8.0)	4 (5.0)
Fair	3 (6.0)	6 (7.5)
Poor	14 (28.0)	33 (41.3)
Total	50 (100)	80 (100)

Cut-off values (cm): Male: Excellent > 17.9; Good 17.0–17.9; Average 15.8–17.0; Fair 15.0–15.8; Poor < 15.0; Female: Excellent > 17.9; Good 16.7–17.9; Average 16.2–16.7; Fair 15.8–16.2; Poor < 15.4

3.4. Associations between flexibility measures (sit-and-reach test) and BMI

The correlation analysis of the results in Table 7 indicates that there are no statistically significant linear relationships between the sit-and-reach test flexibility scores and all the demographic and anthropometric measures studied, such as sex, age, height, weight, and BMI, in the existing undergraduate student population. All r-values were not strong, with a range of -.107 to .090 and corresponding p-values greater than the traditional .05 significance level ($p \geq .090$). The key result is that the relationship between BMI and flexibility is non-significant, and the correlation is negative ($r = -.060$, $p = .501$). This finding is consistent with other researchers who have been studying young adult cohorts and have also reported weak or mixed correlations between overall body mass and measures of joint range of motion (Gite et al., 2021). These results indicate that, in such a relatively young and healthy group, the sit-and-reach performance might be predetermined not only by such general anthropometric factors as elasticity of connective tissues but also by their physiological characteristics. These results, however, conflict with a large body of literature, especially that with older or more heterogeneous sample groups, which often show that high levels of body mass/adiposity and reduced flexibility are virtually correlated (Al-Hazzaa et al., 2011). It can be theorized that the lack of a significant negative correlation is the result of the homogeneity of the sample and the range constraint. The first-year undergraduate sample would have a low variance in both the BMI and physical activity profile over the general population, thus lowering the statistical power required to identify a possible population-level correlation. The main methodological weakness that influenced the interpretation of these findings is the use of Body Mass Index (BMI) as the measure of body composition. BMI is a nonspecific composite variable, which conceptually is incapable of distinguishing between the unique mechanical effects of fat mass (adiposity) and lean body mass (muscle) on joint movement. Although it is known that high adipose tissue has a mechanical impeding effect on the range of motion, thereby implying a strong negative relationship with flexibility, the application of BMI confounds the effects of high adipose tissue with those of muscle mass (which also increases a high BMI).

This pooling probably obliterates the actual inverse relationship between restrictive tissue (fat) and flexibility, and this could result in a false negative result. Thus, further studies will have to move away from crude anthropometry to accurate body composition measurement methods like Dual-Energy X-ray Absorptiometry (DXA) or Bioelectrical Impedance Analysis (BIA). By applying these methods, the researchers could isolate the independent effects of fat mass and fat-free mass on sit-and-reach scores, and this would give a more precise and biomechanically relevant picture of the effect of individual parts of the tissue on the flexibility of the young adults.

Table 7: Associations between flexibility measures (sit-and-reach test) and BMI

Parameters	r-value	p-value
Sex	-.107	.226
Age	-.021	.809
Height	.090	.893
Weight	-.012	.090
BMI (kg/m^2)	-.060	.501

3.5. Sex differences in flexibility (sit-and-reach) and BMI

Table 8 shows that researchers used an independent samples t-test to investigate any possible differences between the sex of the first-year undergraduate population based on measures of flexibility using the sit-and-reach test scores. This analysis aimed to establish whether any significant difference exists between the levels of flexibility of male and female students. The flexibility score of male students ($n = 50$) had a mean of 17.10 ($SD = 4.57$). Comparatively, the mean flexibility score was 16.08 ($SD = 4.75$) with female students ($n = 80$). The independent samples t-test showed that the observed difference between male and female students concerning flexibility was insignificant, $t = 1.22$, $p = .226$. The mean difference has a confidence interval of -.64, 2.70 at 95 percent, which means that the mean flexibility scores of males and females are not statistically significant and thus probably a sampling variability and not a population difference. Although the mean flexibility score was numerically higher among male students than female students, it did not present any statistical significance. This result, relying on the fact that the observed difference is most likely explained by sampling variance but not actual population difference, is compatible with some previous studies that have

reached the same conclusion about there being no significant differences in how flexible people are as a result of sex, in some age groups or athlete populations (Yoo et al., 2022). The present study's findings add to the previous research, implying that sex and BMI are not the first predictors of flexibility in the case of the specific group of first-year undergraduates. It summarizes the need to consider population-specific features when looking at these interactions.

It reveals the complex nature of factors affecting flexibility, which necessitates investigating other possible sources of the factor (e.g., lifestyle, physical activity level, genetic predisposition) in future studies (van Ommen et al., 2014; Bayartai et al., 2020).

Table 8: Sex differences in flexibility (sit-and-reach) and BMI

Sex	n	Mean	SD	t	df	p	95% CI
Male	50	17.10	4.57	1.22	128	.226	-.64, 2.70
Female	80	16.08	4.75				

4. Conclusion

The first-year undergraduate research revealed anticipated sex-based variations in anthropometric data. Males had an average Body Mass Index (BMI) higher than that of females, and females had a lower average body weight. The sit-and-reach (SR) test of flexibility revealed that both males and females exhibited a wide range of scores. More importantly, the evidence indicates that age, sex, and BMI had no significant impact on flexion ability in this group. Although initial correlations revealed partial positive relationships with the other factors under consideration, the results were not statistically significant or showed strong predictive ability. This is significant because it leads to the conclusion that in this population, flexibility could be more susceptible to other variables, including the level of physical activity, certain sport participation, or genetic influences, rather than the more assessed demographic and fundamental anthropometric (sex, age, BMI) variables. The findings highlight the complexity of flexibility as a physiological characteristic. Thus, the follow-ups should take into consideration the inclusion of a wider range of variables as opposed to conventional demographic and anthropometric parameters. Research into such variables as lifestyle patterns or physical activity profiles would be more comprehensive and would produce more useful results to facilitate the creation of specific health and wellness initiatives in the context of a university.

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Compliance with ethical standards

Ethical considerations

The study was conducted in accordance with institutional ethical standards and the principles of the Declaration of Helsinki. Participation was voluntary, and all students provided informed consent after receiving a clear explanation of the study objectives and procedures. Participant safety was ensured through health screening using the Physical Activity Readiness Questionnaire (PAR-Q), and appropriate exclusion criteria were applied. Official permission for participant recruitment and data collection was obtained from the relevant faculty and administrative authorities.

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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