GAZZ MED ITAL - ARCH SCI MED 2008;167:135-42

Comparison between sit-and-reach test and V sit-and-reach test in young adults

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Aim. **V sit and reach test have been proposed as an alternative to the classical sit and reach test because only a meter rule is need and his intraclass internal consistency and hamstring flexibility criterion measures are high. However, because no sit and reach box is used in the V sit-and-reach test and hip position is different from the sit and reach test, spine and pelvis postures could be different between both tests and could influence the score and criterion validity.**

Methods. **A hundred and two men and 96 women young adults performed three trials for the sit-and-reach test (SR), V sit-and-reach test (VSR) and passive straight leg raise (PSLR) (left and right leg) in a randomized order. When the subject reached forward as far as possible, comfort (visual analogue scale), score (ACUFLEX I Flexibility tester), thoracic, lumbar postures and pelvic tilt (with an inclinometer) were measured.**

Results. **The VSR showed a greater spine flexion and anterior pelvic tilt but lower score than SR ($p<0.01$), whereas no differences in comfort were found. The hamstring validity for sit-and-reach test was slightly higher ($r = 0.56$-0.74) than the VSR ($r = 0.53$-0.65) in both men and women.**

Conclusion. **The sit-and-reach test is a more preferable test over the VSR as measure of hamstring flexibility in young adults.**

Key words: **Lumbar spine - Thoracic spine - Pelvis - Posture - Sit-and-reach tests.**

Fundings.—This study was supported by funding from the Catholic University of San Antonio of Murcia (PMAFI-PI-06/1C/03).

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Sit-and-reach tests are widely used measurement tools for evaluating hamstring and lower back flexibility. Different tests, such us classical sit-and-reach test (SR), toe touch test, back-saver sit-and-reach test, modified sit-and-reach test, chair sit-and-reach test and V sit-and-reach test (VSR), have been proposed, evaluated and compared.[1-8] All these tests involve a slow and gradual lumbar, thoracic and hip (pelvis) flexion. Although the administration procedures of these tests are similar, each test possesses unique advantages and disadvantages as compared to other tests.

The President's Challenge Physical Fitness test proposed the VSR for measure the flexibility of the lower back and hamstring muscles. Test procedures and scoring are the same as the classical sit-and-reach test, although there is not a box for measurement and coronal position of the hip in the initial position is different. Hui *et al.*[4] have suggested that the V sit-and-reach test may be preferable to other tests from a practicality standpoint, because it only requires a meter rule. However, these differences could modify the pelvis and spine postures between the SR and the VSR tests.

The literature agreed that SR tests produced moderate validity in hamstring flexibility assessment.[1, 3, 8, 9] Some studies have compared the intraclass reliability, criterion measure and correlation between the VSR with other SR tests.[4, 6, 10] Hui *et al.*[4] suggested that practicioners may wish to use the VSR, because it requires the simplest procedures and no equipment. These studies have used the score as measure. The most common assumption when interpreting SR test results is that subjects with better scores possess a higher degree of trunk and hip flexibility than those with lower scores. However, in addition to the distance reached, the quality of the movement should also be considered.[1]

Score on the SR tests is influenced by a variety of factors [11] such as box use, hip position, spine curves, anthropometric factors, scapular abduction and ankle posture. The degree of pelvic tilting have also been proposed as hamstring flexibility measure in children because provides a reliable and simple measure,[11] although no studies have been conducted to establish their criterion-related validity with the straight leg raise. With regards to the spine posture, only Liemohn *et al.*[12] have compared the lumbosacral movement between two sit and reach tests (the classical sit-and-reach test and the back-saver sit-and-reach test). Other studies have analyzed the spine posture of the sit and reach [9] and the toe touch test [7, 13] using different samples from different populations. To our knowledge, neither study has examined the spine posture or pelvic position in the SR and the VSR. The aims of this study were to compare comfort, score, thoracic, lumbar and pelvis postures between the SR and the VSR and compare the criterion-related validity of hamstring flexibility of score and pelvic position for the classical sit and reach and the V sit and reach tests.

Materials and methods

Subjects

A hundred and two men (mean (SD) age of 22.9 (3.2) years, height of 176.7 (6.3) cm, and mass of 75.3 (9.4) kg) and 96 women (mean (SD) age of 23.2 (4.5) years, height of 164.3 (5.8) cm, and mass of 59.9 (8.5) kg) volunteers to participate in this study were recruited from a University population. The study was approved by the Ethics and Research Committee of the Catholic University San Antonio. Before testing, subjects completed a written informed consent. No subject reported any form of musculoskeletal disorder at the time of testing and not had any history of pathology to the hip, knee, thigh, or spine.

Procedures

After the informed consent, subjects were instructed to perform the SR test, the VSR test and the passive straight leg raise (right and left leg) in a randomized order. Three trials for each test were administered, and the average values of each test were entered for data analyses. During testing, the subjects removed his shoes and the laboratory temperature was kept at 25ºC.

To standardize the measuring scale, a standard meter rule was placed on the sit-and-reach box for the SR and on the floor between the legs for the VSR. The end range position was held about six seconds to measure the spine and pelvic postures. The participants were allowed to rest for 10 minutes between tests.

A Unilevel inclinometer (ISOMED, Inc., Portland, OR) (a circular, fluid-filled goniometer) was used to measure the thoracic and the lumbar spine. Prior to measurements, the participants stood upright while the following bony landmarks were identified and marked with a skin marker: spinous process of the first thoracic vertebrae (T_1), twelfth thoracic vertebrae (T_{12}) and fifth lumbar vertebrae (L_5). In order to measure the degree of the thoracic curve, when the subject reached forward as far as possible, the inclinometer was placed at T_1 and the dial was set at zero degrees (Figure 1), later positioned at T_{12}, obtaining instant reading of the thoracic angle (Figure 2). Then, in order to measure the degree of the lumbar angle, the inclinometer dial was placed

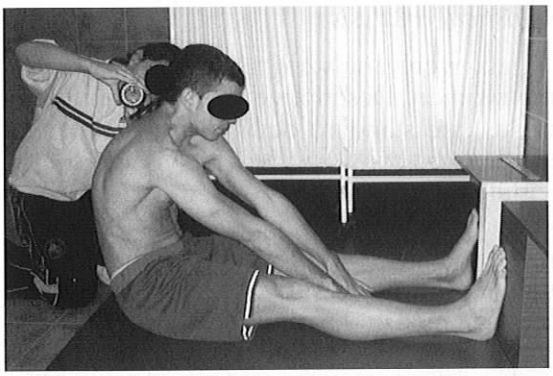

Figure 1.—Reaching position of the V sit-and-reach test with the inclinometer placed at T1.

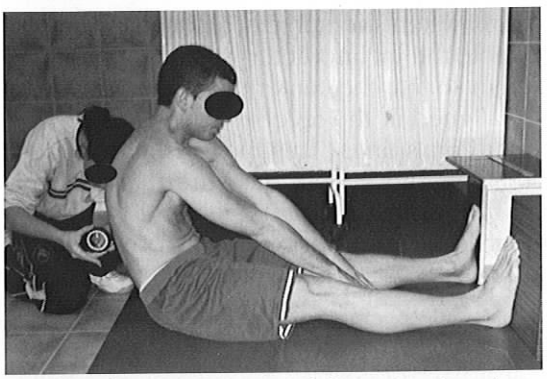

Figure 2.—Reaching position of the V sit-and-reach test with the inclinometer placed at T12.

again at zero degrees at T_{12} and then repositioned at L_5 (Figure 3), obtaining instant reading of the lumbar angle. The legs on the inclinometer were adjusted so as to cradle the spinous processes. The legs were pressed gently but firmly into the interspinal spaces.

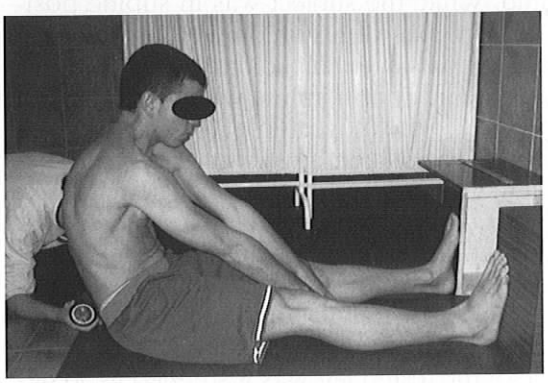

Figure 3.—Reaching position of the V sit-and-reach test with the inclinometer placed at L5.

Measurements

SIT-AND-REACH TEST

Sit-and-reach test required the use of a specially constructed box (ACUFLEX I Flexibility tester, height = 30.5 cm). A centimeter scale was placed on the top surface of the box. The subject was required to sit with knees straight, legs together so that the sole of the foot was flat against the end of the box relative to the 23-cm point. With palms down, placing one hand on top of the other, the subject slowly reached forward as far as possible sliding the hands along the floor with the knees as straight as possible and holds the position for approximately 6 seconds. The final position that the subject reaches was the score for the test. A reach distance of 23 cm corresponded with the position of the feet against the box.

V SIT-AND-REACH TEST

The participant sat on the floor without a box, with the feet separated about 30 cm to form a V-shaped leg position. A meter rule was placed between the legs, with the 23-cm point located at the heel line. A SR box was placed in each foot to standardize the ankles´ position in the same dorsiflexion than in the SR. With palms down, placing one hand on top of the other, the subject slowly reached forward as far as possible sliding the hands along the floor with the knees as straight as possible and holds the position for approximately 6 s.

PELVIC TILT

Pelvic tilt was defined as rotation of the pelvis in a sagittal plane around the mediolateral axis. The pelvic tilt was calculated as the angle of inclination between the sacrum and the horizontal at the point of maximal forward reach and was measured with the inclinometer ISOMED. The inclinometer was set so that 0 degrees represented the hori-

zontal. When the subject reached as far as possible the inclinometer was placed on the sacrum so that the center of the inclinometer was aligned at the level of the posterior superior iliac spines. This measuring provides a reliable and simple measure that reflects hamstring muscle length (11) and is not influenced by anthropometric factors or spine posture.

Hamstring criterion

The criterion measure of hamstring flexibility was determined by executing a maximum passive straight leg raise (PSLR) on each limb. While the subject was in supine position, the axis of a goniometer was aligned with the axis of the hip joint. The tester placed the stationary arm in line with the trunk and positioned the moveable arm in line with the femur. The subject's leg was lifted passively by the tester into hip flexion. The endpoint for straight-leg raising was determined by 1 or both of 2 criteria: (a) the examinator's perception of firm resistance, and/or (b) palpable onset of pelvic rotation. The knee remained straight during the leg raise. The ankle of the tested leg was restrained in 90 degrees of dorsiflexion. Moreover, pelvis was fixed to avoid the posterior pelvic tilt and an auxiliary explorer kept the counter lateral leg straight to avoid external rotation. The criterion score of hamstring flexibility was the maximum angle (degree) read from the goniometer at the point of maximum hip flexion.

Angles were recorded to the nearest degree for each leg. Three trials were given for each leg and the average of the three trials on each side was used for subsequent analyses.

Perceived comfort

Subjects were asking after each SR test about their perceived comfort using a visual analogue scale (VAS), that contained polar extremities of "very uncomfortable" (value: 1) to "very comfortable" (value: 10) and a vertical mark placed on the 100 mm line by the participants indicated their perception of comfort.

Statistical analysis

Data were analyzed separately for men and women. Descriptive statistics including means and standard deviations were calculated for the comfort, score, pelvis and spine posture. Paired *t* tests were used to test for differences between the mean values of the sit-and-reach test and the V sit-and-reach test and between PSLR right and left. Differences between men and women were analyzed using unpaired *t* test. Perceived comfort was analyzed with nonparametric statistics. The Mann-Whitney U test was used to compare the perceived comfort between genders. The Wilcoxon signed rank test was used to compare the perceived comfort between both tests. Pearson correlation coefficient was used to evaluate possible relationships between selected variables. *P* values less than 0.05 were considered statistically significant. Analyses were performed using the SPSS 12.0 statistical software package.

Results

Table I provides the means, standard deviations and significance for the measured variables in the study. The VSR showed a greater pelvic and spine bending ($p<0.001$) but lower score than the SR ($p<0.000$ in men and $p<0.05$ in women). For both tests, score and anterior pelvic tilt were higher in women ($p<0.000$), while thoracic curve was lower ($p<0.000$). For men, the mean (SD) values for the PSLR right and left were 71.97º (9.45) and 72.17º (9.85), respectively ($p = 0.65$). For women, the mean values were 84.05º (14.88) and 84.53º (14.51) respectively ($p = 0.61$). The correlation between both legs was $r = 0.92$ ($p<0.000$) in both genders.

Table II presents the correlations between score, spine and pelvis postures with the PSLR. Correlation values were slightly greater in the SR. Pelvic posture and score in both SR and VSR showed the higher correlation with the PSLR. Women showed greater correlation values than men between the score and the pelvic posture with the PSLR.

TABLE I.—*Means (SD) and significance of score, thoracic curve, lumbar curve, pelvic tilt and comfort between both tests for men (n=102) and women (n=96).*

Variable	Sit-and-reach	V sit-and-reach	P-value between tests
Score (cm)			
Men	22.82 (7.90)	18.64 (8.90)	0.000
Women	29.47 (9.64)	27.80 (10.68)	0.018
P-value between gender	0.004	0.000	
Thoracic curve (degrees)			
Men	69.64 (8.05)	75.27 (8.36)	0.000
Women	59.33 (15.68)	67.03 (10.08)	0.000
P-value between gender	0.000	0.000	
Lumbar curve (degrees)			
Men	28.40 (8.05)	30.77 (7.98)	0.000
Women	29.53 (7.70)	31.79 (6.42)	0.003
P-value between gender	0.48	0.50	
Pelvic tilt (degrees)			
Men	75.43 (9.45)	82.06 (9.87)	0.000
Women	87.65 (13.06)	97.70 (13.18)	0.000
P-value between gender	0.000	0.000	
Comfort (VAS)			
Men	3.84 (1.23)	3.78 (1.05)	0.98
Women	4.24 (1.16)	3.76 (0.97)	0.25
P-value between gender	0.26	0.44	

VAS: visual analogue scale.

Discussion

Several sit-and-reach tests are commonly used in health-related physical fitness test batteries to evaluate the hamstring and low-back flexibility.[6] Our study have compared score, comfort, spine and pelvic postures between the SR and the VSR because procedure differences (hip position, executed with or without box) may influence the score and the criterion-validity. Our results showed that score, spine and pelvic postures are significantly different between both tests. This is probably due to the lower horizontal trunk position when performing the VSR without the use of a sit and reach box. Although there was a higher spine flexion in the VSR, there were no significant differences in the reporting of comfort between both tests.

If a subject is evaluated in both SR tests, the score will be lower in the VSR, and this fact could be interpreted as a reduced hamstring muscle length if similar reference values are used.

Because no box is used in the VSR, trunk and arm positions are different respect to the SR. Since the meter ruler is positioned on the floor and the subject reached as far as possible, there were a greater thoracic, lumbar and pelvic bending although score is significant lower than the SR test. These differences in spine posture between both tests affect to the correlation between score and PSLR. In both genders, the correlations are higher in the SR than the VSR. The greater spine bending in the VSR would influence the score to great extent. The greater r-values between the passive straight leg raise with score and pelvic tilt in women are probably due to their greater hamstring flexibility that reduced the angle of thoracic curve and increased the anterior pelvic tilt at maximum trunk flexion. Clinical observations have suggested that the length of the hamstring muscles influences pelvic flexion and spine posture during forward bending with the knees straight.[14] Tully and Stillman [13] proposed that subjects with greater ability to flex the hips

TABLE II.—*Pearson correlations among score, passive straight leg raise (right and left), spine and pelvic postures in both sit and reach test and V sit and reach test.*

	Men (n= 102)			Women (n= 96)		
	Score	PSLR		Score	PSLR	
		Right	Left		Right	Left
Sit and reach test						
Score	—	0.59†	0.56†	—	0.74†	0.72†
Thoracic curve	-0.24†	-0.10	-0.06	-0.28*	-0.37†	-0.35†
Lumbar curve	0.32†	0.19	0.06	0.14	0.09	0.07
Pelvic tilt	0.81†	0.55†	0.51†	0.89†	0.67†	0.68†
V sit and reach test						
Score	—	0.55†	0.53†	—	0.65†	0.63†
Thoracic curve	-0.11	-0.01	-0.01	-0.35†	-0.20	-0.22
Lumbar curve	0.33†	0.08	0.05	0.29*	-0.02	-0.03
Pelvic tilt	0.75†	0.48†	0.46†	0.81†	0.60†	0.60†

* Correlation is significant at the 0.05 level (two tailed). † Correlation is significant at the 0.01 level (two tailed). PSLR, passive straight leg raise.

with extended knees can reach their toes without needing to use the full available thoracic motion. In concordance with these studies, we found a negative but not significant correlation (except for women in the SR test) between thoracic curve and the passive straight leg raise. The correlations were also negative but significant between the thoracic curve and score (except for men in the VSR). With regards to lumbar curve we not found any correlation between the PSLR and lumbar curve. In concordance with our study, Liemonh *et al.*[12] found that the amount of lumbosacral mobility was similar in both genders.

Previous studies have analyzed the criterion-related validity of the various forms of sit-and-reach tests. They found correlation values ranging from r=0.53 to 0.78 between sit and reach and straight leg raise in studies involving young adults participants.[1, 6, 8, 9] Hui and Yuen [6] reported that the VSR yielded better validity than the SR. They found *r*-values of 0.58-0.63 in men and 0.44-0.52 in women between the VSR score and the passive straight leg raise. With regards to SR score the r-values were 0.47-0.48 in men and 0.46-0.53 in women. Contrariously, our work showed greater correlation values between the PSLR and score for both VSR (r= 0.53-0.55 in men; r= 0.63-0.65 in women) and SR (r= 0.56-0.59 in men; r = 0.72-0.74 in women). These differences might be explained by the different values of the passive straight leg raise between both studies.

Our results suggest that pelvic tilt is affected by initial position of the hips. The greater anterior pelvic tilt in the VSR than the SR ($p<0.000$), is probably due to the slight hip abduction that would reduce hamstrings tightness. The pelvic posture also influences the sagittal shoulder position. Subjects with a reduced anterior pelvic tilt in maximal reaching, will have their shoulder joints more removed from the floor and the ruler, and the angle between the line of their arms and trunk will be smaller, influencing the score.

The correlation between the pelvic tilt and the score with the straight leg raise suggest that both measures reflect hamstring muscle length. The score is conditioned by anthropometric characteristics, limb discrepancies, intervertebral range of motion and hip (pelvis) mobility. However, the pelvic tilt is conditioned by hamstring tightness. Because the hamstring muscle originate on the ischial tuberosity of the pelvis, it is logical that tension in the hamstring muscles will have a direct influence on movement of the pelvis during sit and reach tests. Indeed, greater hamstrings flexibility has been related with increased anterior pelvic tilt.[14] The pelvic po-

sition eliminates some anthropometric factors, intervertebral flexibility or scapular abduction from influencing the score. Cornbleet and Woolsey [11] recommended more attention to the pelvic position rather than the score because provides a reliable and simple measure that reflects hamstring muscle length. They found that the correlation between the pelvic tilt (measured with an inclinometer placed on the sacrum) and the SR score in children was $r = 0.76$. However, we found greater correlation values between PSLR and score than between PSLR and pelvic tilt in both tests. Besides, women showed greater correlation than men between score and PSLR as well as between pelvic tilt and PSLR, perhaps because the women tended to have a greater amount of pelvic anterior tilt and a lower thoracic flexion than men.

Only one study has compared the spine posture between sit and reach tests. Liemohn *et al.*[12] no found significant differences in lumbar curve (assessed with an Ady-Hall Lumbar monitor) during the performance of the back saver sit and reach and the classical sit and reach. Correlation coefficients between score and degrees of lumbar flexion in the SR was $r = 0.68$ in men ($p<0.001$) and $r = 0.33$ in women ($p>0.05$). Our correlation analysis suggested that score of both SR and VSR were poor related to lumbar flexion in maximal reach for both men ($r = 0.32$ to 0.33) and women ($r = 0.14$ to 0.29), although the lumbar curve was measured using an inclinometer. Other studies have examined the relations of the score in the SR and/or VSR with the lumbar criterion measure determined by MacRae and Wright method [2, 4, 5] or Schober-L test [9] and reported low correlations ($r = -0.26$ to 0.47). Tully and Stillman [13] measured the sagittal thoracic, lumbar, and hip angles with a model of reference marker placement and found that hip flexion was directly proportional to toe touch score ($r = 0.71$) but not lumbar ($r = 0.17$) or thoracic ($r = 0.20$) flexion. Some of the variability in the reported correlations of lumbar flexion may have been due to the wide range of methods utilized for measurement.

Ankle posture affects the performance on the SR and the PSLR. The ankle of the tested leg in the PSLR was fixed in dorsiflexion (90 degrees) because previous studies found that asymptomatic young adult had greater flexibility when the ankles were not restrained in dorsiflexion.[15, 16] In the VSR, the ankle was fixed in the same position than the SR because the ankle posture can affect the score. If the foot are permitted to plantar flex (for example, could occur if the feet will not restrained in the VSR), men and women will improve their scores.[17]

In concordance with previous studies in young adults, women had greater score in SR tests and straight leg raise than men.[1, 6, 12, 18] In our study, score mean differences between SR and VSR were 4.18 cm in men and 1.67 cm in women. The greater differences between SR and VSR scores in men would be caused by their lower hamstring extensibility and greater thoracic flexion. In a previous study, Hui and Yuen [6] found a difference of 0.91 cm in men and 3.94 cm in women.

Subjects who can reach their toes but who have short hamstring muscles practice the long-sitting stretch might further increase their back motion, and this could produce little change in their hamstring muscle length, although the score could be improved. Future studies should investigate if sagittal curvatures in standing (normal curves, thoracic hyperkyphosis, lumbar hyperlordosis or hypolordosis) could influence the spine posture, score and criterion-related validity in maximal reach.

Conclusions

The results from this study demonstrate that the sit-and-reach test may be a more preferable test because has greater criterion-related validity as a measure of hamstring flexibility than the V sit-and-reach test in young adults. Furthermore, the sit and reach test shows a reduced lumbar and thoracic range of motion than the VSR and reduce its influence about the score.

Riassunto

Confronto tra sit-and-reach test e V sit-and-reach test in giovani adulti

Obiettivo. Il V sit-and-reach test è stato proposto come alternativa al classico sit-and-reach test poiché è necessario solo un metro lineare e la sua consistenza intraclasse interna e le misure di criterio per la flessibilità degli ischiocrurali sono alte. Comunque, poiché non viene utilizzata la cassa di misurazione del sit-and-reach test nel V sit-and-reach test e la posizione delle anche è differente rispetto al sit-and-reach test, le posture della colonna vertebrale e del bacino possono essere diverse nei due tests e possono influenzare la validità dello score e di criterio.

Metodi. Centodue uomini e 96 donne giovani adulti sono state sottoposti a tre trials per il sit-and-reach test (SR), V sit-and-reach test (VSR) e test di sollevamento passivo della gamba tesa (PSLR) (gamba sinistra e destra) in ordine casuale. Quando il soggetto raggiungeva la massima posizione in avanti, venivano misurati il comfort (scala analogica visiva), lo score (ACUFLEX I Flexibility tester), le posture del rachide toracico, lombare e il tilt pelvico (con un inclinometro).

Risultati. Il VSR ha mostrato una maggior flessione della colonna vertebrale e un maggior tilt anteriore pelvico ma un minor score rispetto a SR ($p<0,01$), mentre non sono state trovate differenze in termini di comfort. La validità per gli ischiocrurali per il sit-and-reach test è stata leggermente più alta (r=0,56-0,74) rispetto a VSR (r=0,53-0,65) sia negli uomini che nelle donne.

Conclusioni. Il sit-and-reach test è un test preferibile rispetto al VSR come misura della flessibilità tendinea in giovani adulti.

Parole chiave: Midollo spinale lombare - Pelvi - Postura - Sit-and-reach tests.

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