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Original Article

Reference values for the Y Balance Test and the lower extremity functional scale in young healthy adults

Ali H Alnahdi, PT, PhD[1)*], Asma A Alderaa, PT, MSc[1)], Ali Z Aldali, PT, MSc[1)], Hana Alsobayel, PT, PhD[1)]

[1)] *Department of Rehabilitation Sciences, College of Applied Medical Sciences, King Saud University: P.O. Box 10219, Riyadh 11433, Saudi Arabia*

Abstract. [Purpose] This study aimed to establish gender-specific reference values for the Y Balance Test (YBT) and the Arabic version of the Lower Extremity Functional Scale (LEFS-Ar) in healthy young adults in Saudi Arabia, and to examine gender differences in the YBT and LEFS-Ar values. [Subjects and Methods] Healthy young adults (31 females, 30 males) completed the YBT and LEFS-Ar in 1 test session. Descriptive statistical analysis (mean, standard deviation, 95% confidence interval) was used to compute the YBT and LEFS-Ar reference values. Independent t-tests were used to examine gender differences in the YBT and LEFS-Ar values. [Results] Gender-specific reference values were obtained for the right, left, dominant, and non-dominant leg as well as for the average performance of both the legs. males showed greater YBT normalized reach distances than females did in the anterior, posteromedial, and posterolateral directions; furthermore, males showed higher YBT composite scores than females did. However, the LEFS-Ar values did not differ between males and females. [Conclusion] Gender-specific reference values were obtained for the YBT and LEFS-Ar in healthy young adults in Saudi Arabia. males performed better than females did in the YBT. However, no gender differences were noted in LEFS-Ar.
Key words: Dynamic balance, Normative data, Activity limitation

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INTRODUCTION

Lower-extremity musculoskeletal dysfunctions are commonly encountered by various health care providers and are known to negatively impact the quality of life[1, 2)]. According to the international classification of functioning, disability, and health (ICF) model[3)], comprehensive assessment of musculoskeletal dysfunctions requires clinicians to quantify the effect of the dysfunction on the various health-related domains, namely, impairment of body structure and function, activity limitation, and participation restriction.

People with lower-extremity musculoskeletal dysfunctions commonly show impaired balance[4, 5)]. The Y Balance Test (YBT), derived from the Star Excursion Balance Test (SEBT)[6)], has been reported to be a valid and reliable measure of dynamic balance[6–9)]; furthermore, the results of the YBT have been reported to be related to lower-extremity impairments[10, 11)] and to be predictors of injuries[12, 13)]. For application of the YBT in daily clinical practice, reference values are required for an accurate interpretation of the test results. These normative values would be used by clinicians to determine the performance levels of patients. Because YBT performance differs among cultures[14)], establishment of culture-specific YBT reference values is required.

Activity limitation, an important health-related domain, can be quantified using patient-reported outcome measures in people with lower-extremity musculoskeletal dysfunctions[15–18)]. The Lower Extremity Functional Scale (LEFS) is a region-specific patient-reported outcome measure that can be used to determine activity limitation in people with lower-extremity musculoskeletal dysfunctions[19–21)]. This scale was recently cross-culturally adapted into the Arabic language (LEFS-Ar)[22)]. LEFS-Ar showed excellent measurement properties, suggesting its usefulness for both daily clinical practice and for research purposes[22)]. Similar to YBT, LEFS-Ar use in daily clinical practice could be enhanced by establishment of reference values that can be used to analyze the scores of the patients.

Therefore, this study aimed to establish gender-specific reference values for the YBT and LEFS-Ar in healthy young adults in Saudi Arabia, and to examine gender differences in the YBT and LEFS-Ar values.

SUBJECTS AND METHODS

The study design was cross-sectional, wherein all the participants were tested in a single testing session. Healthy males and females who were 18–29 years old were recruited for this study. Subjects were excluded if they showed any

*Corresponding author. Ali H Alnahdi (E-mail: alialnahdi@ksu.edu.sa)

lower-extremity or spinal dysfunction or had undergone any surgery, had a history of dizziness or falls, showed any visual or inner ear problems, showed any neurological dysfunctions, showed altered feet sensation, or were pregnant. The participants were college students at King Saud University in Riyadh, Saudi Arabia. All of the participants signed informed consent forms approved by the College of Applied Medical Sciences Human Subjects Review Board at King Saud University before participation.

The procedure of the testing session was as follows: completion of a general information form by each participant, YBT practice trials, completion of LEFS-Ar, followed by YBT actual test trials, in that order; the session ended with measurement of the weight, height, and lower-extremity length of each participant.

The YBT was conducted according to a published protocol[7]. Barefooted participants started the YBT with 6 practice trials in each direction before they underwent the formal testing. The order of the practice trials was right anterior reach (6 trials), left anterior reach (6 trials), right posteromedial reach (6 trials), left posteromedial reach (6 trials), right posterolateral reach (6 trials), and left posterolateral reach (6 trials). The formal testing trials were performed in the same order as the practice trials, with 3 trials performed in each direction. In each trial, the participants were instructed to reach as far as they could by using their reach foot while keeping their reach foot in contact with the reach indicator, and then return to the starting point while they maintained their balance on the stance limb. The maximum reach distance was recorded to the nearest 0.5 cm in each reach trial. The maximum reach distance of the 3 formal trials in each direction was used for the analysis. Reach distances recorded in centimeter (cm) were also normalized to each participant's leg length by dividing the reach distance by limb length and then multiplying by 100 to account for the influence of the leg length on test performance[23]. Normalized composite reach distance was computed for each leg as the sum of the maximum reach distances (in centimeter [cm]) in the 3 directions, divided by 3 times the limb length, and then multiplied by 100.

The LEFS-Ar is a 20-item region-specific scale[19]. Each item was scored on a scale of 0–4, where 0 indicates extreme difficulty or inability to perform the activity, and 4 indicates no difficulty. The scores of the items were summed up to yield a total score, ranging from 0 to 80, with lower scores representing greater degrees of activity limitation. LEFS-Ar has been shown to be a valid and reliable measure of activity limitation in patients with lower-extremity musculoskeletal dysfunction[22].

Lower-limb length was measured from the anterior superior iliac spine to the most distal part of the medial malleolus for each participant by using a tape measure while the participant lay in the supine position. Measurement of the limb length using tape measure has shown excellent reliability[12]. The dominant lower extremity for the participants was determined on the basis of their response to the question "which foot do you use to kick a ball with".

The required sample size to estimate the mean YBT reach distance with 95% confidence level (CI) was computed using a standard deviation of 7 cm[7] and an acceptable error of 2.5 cm above and below the mean[24, 25]. This computation revealed a required sample size of 30 participants. The required sample size to estimate the mean LEFS-Ar score with 95% confidence level (CI) was computed using a standard deviation of 5 scale points and an acceptable error of 5 scale points above and below the mean[24, 25]. This computation revealed a required sample size of 24 participants.

Because the aim of this study was to establish gender-specific reference values, a sample consisting of 30 males and 30 females would be adequate for the establishment of gender-specific reference values for the YBT and LEFS-Ar. The reference values for males and females were obtained by computation of means, standard deviations, and 95% CI for each reach direction in the YBT and also for the LEFS-Ar scores. Independent t-tests were used to examine gender differences in YBT and LEFS-Ar, whereas paired t-tests were used to examine interlimb differences in the YBT.

Table 1. Characteristics of the participants

Variable	Females Mean ± SD	Males Mean ± SD
Age (year)	20.61 ± 1.1	21.40 ± 1.4*
Height (m)	1.56 ± 0.04	1.74 ± 0.08*
Mass (kg)	54.8 ± 12.9	77.6 ± 19.9*
Body-mass index (kg/m^2)	22.4 ± 4.8	25.6 ± 5.6*
Leg length (cm)	87.6 ± 3.4	93.2 ± 5.2*

SD: standard deviation
*Significant difference between males and females ($p < 0.05$)

RESULTS

Thirty-one females and 30 males participated in this study (Table 1). The males were slightly older, had higher body weight, and were taller than the females were (Table 1). Reference values for the YBT for both the females and males are shown as percentage of the leg length in Table 2. Gender-specific reference values for the LEFS-Ar are also presented in Table 2. The females showed no interlimb differences (right versus left) or (dominant versus non-dominant leg) in all directions of the YBT ($p > 0.25$), whereas the males showed significant interlimb differences only in the posteromedial direction (right versus left, $p = 0.04$; dominant versus non-dominant leg, $p = 0.03$; Table 3). Based on these results, the reference values were obtained for each leg separately in addition to the references values corresponding to the average performance of both the legs.

In the anterior direction of the YBT, the males showed better performance in terms of only the average performance of both the legs than the females did ($p = 0.04$; Table 2). In the posteromedial direction of the YBT, the males showed better performance than the females did, when the values of the right, left, dominant, and non-dominant leg and the average of performance of both the legs were compared ($p < 0.001$; Table 2). Similarly, the males showed better performance in the posterolateral direction of the YBT than the females did, when the values of the right, left, dominant, and non-dominant leg and the average performance of both the legs were compared ($p < 0.001$; Table 2). The YBT compos-

Table 2. Reference values for the Y Balance Test (expressed as a percentage of the leg length [%LL]) and LEFS-Ar

Variable	Females		Males		Gender difference
	Mean ± SD	95% CI	Mean ± SD	95%CI	Mean difference (95% CI)
Anterior (%LL)					
Right	70.1 ± 4.1	68.6–71.6	73.1 ± 7.3	70.4–75.8	2.9 (−0.08 to 6.0)
Left	70.4 ± 4.3	68.8–71.9	73.5 ± 8.5	70.4–76.7	3.2 (−0.32 to 6.6)
Dominant	70.2 ± 4.3	68.6–71.7	73.0 ± 7.5	70.2–75.8	2.8 (−0.3 to 6.0)
Non-dominant	70.3 ± 4.1	68.8–71.9	73.6 ± 8.3	70.6–76.7	3.3 (−0.1 to 6.7)
Average[a]	70.3 ± 3.9	68.8–71.7	73.3 ± 7.0	70.7–75.9	3.1 (0.1 to 6.0)*
Posteromedial (%LL)					
Right	93.7 ± 7.3	91.0–96.4	104.2 ± 8.4	101.1–107.4	10.5 (6.5 to 14.6)*
Left	92.9 ± 7.8	90.0–95.8	107.0 ± 8.7	103.8–110.2	14.1 (9.8 to 18.3)*
Dominant	93.4 ± 7.4	90.7–96.1	104.3 ± 8.6	101.0–107.5	10.8 (6.7 to 14.9)*
Non-dominant	93.2 ± 7.9	90.3–96.1	107.0 ± 8.5	103.8–110.2	13.8 (9.6 to 18.0)*
Average	93.3 ± 7.3	90.6–96.0	105.6 ± 7.8	102.7–108.6	12.3 (8.4 to 16.2)*
Posterolateral (%LL)					
Right	92.3 ± 8.0	89.4–95.3	105.0 ± 10.0	101.3–108.8	12.6 (8.0 to 17.3)*
Left	92.8 ± 9.0	89.5–96.1	105.3 ± 11.6	101.0–109.7	12.5 (7.2 to 17.8)*
Dominant	92.3 ± 8.5	89.2–95.4	105.8 ± 10.5	101.9–109.7	13.5 (8.7 to 18.4)*
Non-dominant	92.9 ± 8.6	89.8–96.0	104.5 ± 11.2	100.4–108.7	11.6 (6.5 to 16.7)*
Average	92.6 ± 8.0	89.6–95.5	105.2 ± 10.3	101.3–109.0	12.6 (7.8 to 17.3)*
Composite (%LL)					
Right	85.4 ± 5.7	83.3–87.5	94.1 ± 7.2	91.4–96.8	8.7 (5.4 to 12.1)*
Left	85.4 ± 6.3	83.0–87.7	95.3 ± 7.4	92.5–98.1	9.9 (6.4 to 13.4)*
Dominant	85.3 ± 6.0	83.1–87.5	94.1 ± 7.0	91.5–96.8	8.8 (5.5 to 12.2)*
Non-dominant	85.5 ± 6.1	83.2–87.7	95.3 ± 7.6	92.5–98.1	9.8 (6.3 to 13.3)*
Average	85.4 ± 5.8	83.2–87.5	94.7 ± 7.0	92.1–97.3	9.3 (6.0 to 12.6)*
LEFS-Ar	74.3 ± 6.6	71.9–76.7	74.8 ± 5.2	72.8–76.7	0.44 (−2.6 to 3.5)

%LL: percentage of leg length; CI: confidence interval; LEFS-Ar: Arabic version of the Lower Extremity Functional Scale

[a]Average of both the legs; *Significant difference between males and females ($p < 0.05$)

Table 3. Interlimb differences in the Y Balance Test performance

Variable	Females	Males
	Mean difference (95% CI)	Mean difference (95% CI)
Right minus left		
Anterior (cm)	−0.2 (−1.2 to 0.8)	−0.4 (−3.0 to 2.1)
Posteromedial (cm)	0.7 (−0.7 to 2.2)	−2.5 (−4.9 to −0.1)*
Posterolateral (cm)	−0.4 (−2.2 to 1.4)	−0.3 (−2.6 to 2.0)
Composite score (%LL)	0.0 (−1.1 to 1.2)	−1.2 (−2.7 to 0.4)
Dominant minus non-dominant		
Anterior (cm)	−0.2 (−1.2 to 0.8)	−0.6 (−3.2 to 1.9)
Posteromedial (cm)	0.2 (−1.2 to 1.7)	−2.6 (−5.0 to −0.2)*
Posterolateral (cm)	−0.6 (−2.4 to 1.2)	1.2 (−1.1 to 3.5)
Composite score (%LL)	−0.2 (−1.3 to 0.9)	−1.2 (−2.8 to 0.4)

CI: confidence interval; %LL: percentage of leg length

*Significant interlimb difference ($p < 0.05$)

ite score also showed better performance of the males than of the females, when the values of the right, left, dominant, and non-dominant leg and the average performance of both the legs were compared ($p < 0.001$; Table 2). The LEFS-Ar values did not show any differences between the males and the females ($p = 0.77$; Table 2).

DISCUSSION

In the present study, gender-specific reference values were obtained for the YBT and LEFS-Ar in healthy young adults in Saudi Arabia. These gender-specific reference values would enhance the interpretation of the YBT and LEFS-Ar measurements in daily clinical practice and provide reference values against which the performance of patients could be compared; furthermore, these reference values could be used as reach targets during the course of rehabilitation of patients.

The YBT reference values in the current study were presented as means and 95% CI. YBT scores that fall within the boundaries of the 95% CI suggest performance similar to that of healthy individuals, whereas YBT scores lower than the lower limit of the 95% CI are indicative of dynamic balance lesser than the dynamic balance of healthy individuals. Research papers on YBT scores of participants from either Saudi Arabia or other countries with similar culture and lifestyle could not be found. A comparison with general college students from the USA with similar characteristics as the participants in the current study[26] showed that Saudi males and females showed lower YBT composite scores and lower scores in the posteromedial and posterolateral directions than their USA counterparts did. However, the performance in the anterior direction of the YBT of Saudi males and females was rather similar to that of their USA counterparts. The difference in the YBT performance could be attributed to cultural and lifestyle differences[14]. This observation supports the aim of the current study that culture-specific reference values for the YBT are needed.

The YBT reference values for the right, left, dominant, and non-dominant leg and also for the average performance of the 2 legs were obtained. The average performance of the 2 legs is commonly reported in the literature[27–29]. In the current study, no differences were noted between the limbs, except in the posteromedial direction in only the males. This observation indicates that the average composite score and the average scores corresponding to the anterior and posterolateral performance in both males and females as well as the average score corresponding to the posteromedial performance in females could be used as reference values. In the posteromedial direction, males performed better while standing on the left than on the right leg and while standing on the non-dominant leg than on the dominant leg. Seventy-seven percent of the males in the current study stated that their left leg was their non-dominant leg, which might explain the better performance while standing on the left than while standing on the right leg. Previous research studies using SEBT showed no difference in the dynamic balance performance between the dominant and the non-dominant leg[30–32]. These studies included only female participants[30] or did not conduct within-gender comparisons[32]; furthermore, in these studies, the participants performed the test in only 3 directions of the SEBT, excluding the posteromedial direction, in which the interlimb difference in the males was found to be significant in this study[30, 31]. Another study also using SEBT showed significant interlimb differences in the medial direction in healthy control subjects[33]. Further studies are needed to examine the pattern of interlimb differences in males and females during the performance of the YBT.

In addition to providing reference values for the YBT (percent leg length), this study yielded data on the normal interlimb difference in healthy individuals during performance of the YBT. Thus, this study provided valuable information on the differences between the limbs of an individual[6]. Interlimb differences observed in this study seem to be lower than those observed in other studies[14, 27]. Data presented in Table 3 could help clinicians in determining whether the interlimb difference observed in patients with lower-extremity dysfunction falls within or beyond the limits of the normal interlimb difference. Interlimb difference greater than the absolute value of either the upper or the lower limit (whichever is higher) of the 95% CI could be considered beyond the normal range of interlimb difference in YBT performance. For instance, an interlimb difference between the right and left leg of >3 cm in males and of >1.2 cm in females is beyond the normal interlimb differences in the anterior direction (Table 3). An interlimb difference of >4 cm in YBT anterior direction was associated with an increased risk of lower-extremity injury[12, 34]; these results suggest that interlimb comparison could be a useful and rapid screening tool for lower-extremity dysfunctions.

The males in the current study showed higher normalized reach scores in all 3 direction of the YBT and also showed higher composite reach scores than the females did. Furthermore, the males showed greater absolute interlimb reach difference in the posteromedial direction of the YBT than the females did. These results are in line with the previous results, which indicated that males showed greater normalized reach distances in the posteromedial and posterolateral directions and higher composite reach scores than the females did[27]. In another study, males seemed to show higher composite scores and greater normalized reach distances in all directions than females did, although this difference was not statistically tested by the authors[26]. Data of the previous study yielded between gender differences with meaningful effect sizes[26]. Many previous studies[27, 35] indicated greater interlimb differences in males than in females in the anterior reach direction, whereas the results of the current study indicate gender difference in the magnitude of interlimb difference in only the posteromedial direction.

The LEFS-Ar score ranges from 0 to 80, with lower scores representing higher levels of activity limitation[19, 22]. When patient-reported outcome measures are used, clinicians are faced with the challenge of determining a target for their patients[36]. With improvement in patient's physical function, LEFS-Ar score is expected to increase, and this increase could be judged as real and important by comparing it to the minimal detectable change on the scale and minimal clinically important difference[19, 22]; however, the question about what should be the target for the patient remains unanswered. The 95% CI of the mean LEFS-Ar score obtained in the current study could be used by clinicians as the target for their patients. LEFS-Ar scores of 72–77 in females and 73–77 in males could serve as targets during treatment of lower-extremity dysfunctions in young adults who have similar characteristics as the participants in this study.

The current study established gender-specific reference values for the YBT and LEFS-Ar in healthy young adults

in Saudi Arabia. However, further efforts are needed to establish reference values for the same outcome measures in different age groups to enhance the clinical usefulness of these measures in daily clinical practice.

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