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ORIGINAL RESEARCH

Normative data for neck muscles endurance in healthy Saudi males: foundations for precision health

Ahmad H. Alghadir[1], Hamayun Zafar[1], Talal Alghadir[2], Faisal Alghadir[2], Amir Iqbal[1,*]

[1]Department of Rehabilitation Sciences, College of Applied Medical Sciences, King Saud University, 11433 Riyadh, Saudi Arabia
[2]College of Medicine, King Saud University, 11433 Riyadh, Saudi Arabia

***Correspondence**
ajamaluddin@ksu.edu.sa
(Amir Iqbal)

Abstract

Background: Distinctive cultural practices in Gulf countries, including Saudi Arabia such as wearing the shimagh and participating in traditional dances like the Ardah place considerable demands on neck muscle endurance. Insufficient endurance can contribute to or exacerbate neck pain. The absence of normative data for the Saudi population underscores a critical gap, emphasizing the need for data to guide prevention, diagnosis and culturally tailored interventions. The aim of this study was to establish normative data and assess both interrater and intrarater reliability for neck flexor and extensor muscle endurance in healthy Saudi males. **Methods**: Ninety healthy adults aged 20 years and older with no history of neck pain or injury participated in the study. Two raters (Rater 1 and Rater 2) assessed the endurance of the neck's extensor and flexor muscles in each participant separately using a stopwatch across two sessions (day one and day 3). To mitigate order effects, a random number was assigned to each test for each participant. Participants rested for five minutes between the two readings and ten minutes between the two sets. **Results**: The standard error of measurement (SEM) and minimal detectable change (MDC) for neck flexor muscle endurance were 16.54 seconds and 45.84 seconds, respectively. For neck extensor muscle endurance, the SEM and MDC were 17.43 seconds and 48.31 seconds, respectively. The interrater and intrarater reliability for assessing the endurance of the neck flexor and extensor muscles ranged from good to excellent, with intraclass correlation coefficients ($ICC_{2,1}$) value between 0.85 and 0.96. **Conclusions**: This study provides normative data for neck flexor and extensor muscle endurance, demonstarting good to excellent interrater and intrarater reliability. These benchmarks lay the groundwork for evaluating neck muscle function and clinically enable precise monitoring of endurance changes, guiding tailored interventions to prevent or manage neck pain, particularly in culturally relevant contexts.

Keywords

Neck muscles; Intertester reliability; Intratester reliability; Physical endurance

1. Introduction

Neck pain (NP) is a significant musculoskeletal disorder, affecting approximately 30% to 50% of adults and elderly individuals worldwide [1]. In Saudi Arabia, NP is common among office workers (30%), healthcare workers (50%) and university students (45%), primarily due to sedentary lifestyles, job-related stress, prolonged use of devices and poor posture [2–4]. This condition is frequently associated with complications such as reduced cervical range of motion (ROM) and headache [5, 6]. Weakness in neck muscles may contribute to or exacerbate neck and head pain [6, 7]. Therefore, enhancing neck muscle endurance is regarded as a crucial aspect of neck rehabilitation [8–10].

While impairments in neck muscle strength in patients with NP have been established [11]; changes in muscle endurance have not been thoroughly documented. Reduced endurance in neck extensor muscles has been observed in individuals with NP [12]. Furthermore, a comparative study noted decreased endurance in both extensor and flexor neck muscles in individuals with NP when documented compared with asymptomatic individuals [13]. Additionally, individuals with idiopathic NP and those with whiplash injuries have exhibited diminished deep flexor muscle endurance [14].

Despite these findings, no studies have specifically investigated neck muscle endurance among healthy Saudi males, nor are any normative data on neck muscle endurance for the broader Saudi population.

Normative data for neck flexor and extensor muscle endurance in healthy Saudi males will address significant gaps in both regional and global health knowledge by providing a baseline tailored to a population with unique cultural practices, lifestyles, and biomechanical demands. This data will assist in identifying deviations in muscle endurance associated with neck pain, which may be influenced by activities such as wearing a shimagh and maintaining it in place during traditional dances like Ardah. Globally, musculoskeletal health studies often focus on Western or generalized populations, limiting their applicability to regions with distinct cultural and occupational influences. By establishing region-specific normative data, healthcare professionals in Saudi Arabia and similar regions can more effectively evaluate, diagnose, and treat neck disorders, ensuring culturally relevant and accurate interventions.

Consequently, this study fills a significant gap in the literature by identifying normative data for the endurance of the neck extensor and flexor muscles in healthy Saudi males. Additionally, it assesses the interrater and intrarater reliability of neck flexor and extensor muscle endurance. Establishing these normative values provides healthcare professionals with a valuable reference point for diagnosing and treating neck pain more effectively. Moreover, the assessment of interrater and intrarater reliability ensures that these endurance measurements are consistent and reliable, further supporting their use in clinical practice for evaluating neck muscle function in Saudi males.

2. Materials and methods

2.1 Study design

This study utilized a cross-sectional design to assess normative data on neck muscle endurance in healthy Saudi males.

2.2 Study setting

Participants were recruited through emails using university database. Additionally, banners and posters displayed at public meeting points and administrative building within the university campus to attract participants. Handbills and leaflets were also distributed at screening sites to increase awareness of the study. Participants were screened and recruited at the physiotherapy clinic, College of Applied Medical Sciences, King Saud University, Riyadh, Saudi Arabia. Screenings and assessments took place on two sets of alternate days each week (day 1 & 3 and day 2 & 4). Each participant was assessed on two alternate days. The study was conducted over a three-month period from 19 March 2018 to 10 June 2018.

2.3 Study participants

Ninety healthy Saudi males aged between 18–37 years with no history of NP or injury, disease, or musculoskeletal disorders were assessed by two examiners in this cross-sectional study. All participants were university staff or students. Exclusion criteria included current NP, thoracic pain, headache, functional impairments restricting daily activities, connective tissue or systemic disorders, muscular disorders, a history of concussion, cervicothoracic spinal surgery, diabetes mellitus, or unwillingness to participate. Diabetic patients were excluded because diabetes, which has a high prevalence (15.3%) among Saudi males, is associated with physiological changes such as impaired glucose metabolism, chronic inflammation, and nerve damage (neuropathy). These factors can reduce muscle strength and endurance [15], potentially skewing the normative values for neck flexor and extensor endurance, thereby limiting the generalizability of the data.

2.4 Procedure

Two senior physiotherapists, each with over ten years of clinical experience, served as raters (Rater 1 and Rater 2). They independently assessed the endurance of the neck extensor and flexor muscles for each participant using a stopwatch. Assessments were conducted in two separate sessions, on Day 1 and Day 3. To avoid order effects, a random number was assigned for each test for each participant. Participants rested for five minutes between two readings and ten minutes between the two tests [12, 16, 17]. To enhance the validity of the results, external factors were meticulously controlled before initiating the neck endurance testing protocol. All tests were conducted in a standardized, quiet, temperature-controlled room to minimize environmental variability. Potential distractions were minimized by restricting access to the testing area, limiting personnel to essential staff, and maintaining a distraction-free zone. Uniform instructions were provided to all participants before testing, and unnecessary verbal interaction during the tests were avoided. Consistency was ensured in timing, equipment setup and tester behavior across all sessions. A stopwatch was used to record the neck muscles endurance time in seconds. To minimize measurement bias, raters underwent standardized training, and interrater and intrarater reliability checks were conducted, ensuring consistent and accurate recording of endurance time during the tests.

2.5 Endurance test for flexor muscles of the neck

This test was performed with participants in the supine position [11, 14, 18, 19]. Participants were instructed to maintain maximum chin tuck and lift the head until it was approximately 2.5 cm off the plinth (Fig. 1). Verbal cues such as “hold your head up” or “tuck your chin in” were provided during the test if the participant lost the chin tuck position. The test was terminated if the participant’s head touched the examiner’s hand for more than 1 second or if the participant requested to stop due to fatigue or pain. The holding time was recorded in seconds using a stopwatch.

2.6 Endurance test for extensor muscles of the neck

This test was conducted with participants in a prone position, with their head extruded beyond the edge of the plinth and their arms alongside the body [12, 17, 20]. A Velcro strap was secured around the participant’s head, and a 4 kg weight cuff was suspended from it [21]. Participants were asked to extend their head just above the examination table (Fig. 2). Endurance time was recorded in seconds using a stopwatch. The test was stopped if the participant could not maintain the head in a horizontal position or if they requested to end the test due to pain or fatigue. Written informed consent was obtained from the participant for the publication of images demonstrating the neck flexor and extensor muscle endurance tests.

FIGURE 1. Participant position for the neck flexor muscle endurance test. The examiner's hand is positioned to detect changes in the participant's head position.

FIGURE 2. Participant position for the neck extensor muscle endurance test.

2.7 Statistical analysis

Statistical analysis was performed using SPSS (Version 22. IBM Inc., Chicago, IL, USA). Descriptive statistics, including means, standard deviations (SD), and data percentile categorization are reported. The intraclass correlation coefficient ($ICC_{2,1}$) was used to evaluate interrater reliability. The required sample size was determined at 69 participants for the ICC via the formula published previously [Sample size (N) = $4Z\alpha^2S^2/W^2$] [19], with a confidence level of 95%, a desired total width of confidence interval (W) of 5, and a standard deviation of the variable (S) of 10.57 [20]. A *t*-test was conducted to compare neck flexor and extensor endurance. Absolute reliability was evaluated using the Bland-Altman plot method [21–23]. Standard error of measurement (SEM) and the minimal detectable change (MDC) (MDC = $1.96 \times \sqrt{2} \times$ SEM) were used to assess the absolute measurement error [24, 25]. All tests were deemed statistically significant if the p value was less than or equal to 0.05.

3. Results

Table 1 presents the data for neck flexor and extensor muscle endurance (NFME and NEME) among healthy Saudi males, which appears to approximate a normal distribution, based on the mean and standard deviation values (For NFME: Mean (R1) = 68.57 seconds and SD = 28.13 seconds; Mean (R2) = 65.85 seconds and SD = 27.59 seconds; For NEME: Mean (R1) = 104.31 seconds, SD = 31.51 seconds; Mean (R2) = 104.61 seconds, SD = 32.25 seconds), which suggest symmetrical dispersion. Participants demonstrated substantially better endurance in neck extension compared to neck flexion, with mean endurance times for extension exceeding those of flexion by approximately 36 seconds across both raters. The variability was slightly higher for neck extension, with standard deviations around 31.51–32.25 seconds, compared to 27.59–28.13 seconds for neck flexion. Both raters produced comparable results for each measurement, with minor differences in mean and variability.

Additionally, the analysis of neck flexion and extension muscle endurance highlighted key percentile values, as shown in Table 1. For NFME recorded by R1, the 75th percentile was approximately 87.54 seconds, and the 90th percentile was 104.62 seconds. Similarly, R2's corresponding 75th and 90th percentiles were 84.46 and 101.21 seconds, respectively. For NEME, R1 recorded 75th and 90th percentiles of 125.56 and 144.69 seconds, while R2's values were 126.36 and 145.94 seconds.

Table 2 highlights the reliability of neck muscle endurance measurements, focusing on interrater and intrarater consistency. Interrater and intrarater reliability for the neck flexor and extensor muscles endurance was rated as good to excellent ($ICC_{2,1}$ = 0.85–0.96). The SEM reflects the precision of a single measurement, with values of 16.54 seconds for NFME and 17.43 seconds for NEME, indicating the expected variability due to random error. The MDC represents the smallest measurable change that signifies true improvement or decline beyond measurement error, with values of 45.84 seconds for NFME and 48.31 seconds for NEME. These thresholds provide clinicians with reliable benchmarks to assess changes in endurance, ensuring that observed differences reflect actual progress or deterioration rather than measurement variability. All the ICCs along with the corresponding SEMs and MDC values, are detailed in Table 2.

The Bland-Altman plots in Figs. 3,4, illustrating the interrater agreement for neck flexor and extensor muscle endurance, demonstrate overall strong agreement between raters. For neck flexor endurance, the mean difference (bias) is approximately 2.71 seconds, with limits of agreement ranging from −28.51 to 33.94 seconds, indicating minimal variability. Similarly, for neck extensor endurance, the bias is close to zero (−0.30 seconds), with limits of agreement between −37.03 and 36.43 seconds, reflecting negligible systematic error. Most data points for both measures fall within the limits of agreement, indicating good reliability. However, some scatter at higher mean values in both plots highlights potential variability, emphasizing the importance of maintaining consistent protocols and providing adequate rater training to ensure robust measurements. Figs. 3,4 show the Bland-Altman plots for interrater agreement in neck flexor and extensor muscle endurance, respectively, further supporting the good agreement between raters.

TABLE 1. Descriptive statistics for neck flexion and extension muscle endurance (N = 90).

Variables (N = 90)	Mean	SD	SE	95% CI	Percentile Categorization				
					10th	25th	50th	75th	90th
Age (yr)	24.17	4.22	0.44	23.31, 25.03	18.76	21.32	24.17	27.02	29.58
Height (cm)	169.68	19.52	2.06	165.64, 173.72	144.66	156.51	169.68	182.85	194.70
Weight (kg)	76.69	12.58	1.33	74.08, 79.30	60.57	68.20	76.69	85.18	92.81
NFME_R1 (sec)	68.57	28.13	2.96	62.77, 74.37	32.52	49.60	68.57	87.54	104.62
NFME_R2 (sec)	65.85	27.59	2.90	60.17, 71.53	30.49	47.24	65.85	84.46	101.21
NEME_R1 (sec)	104.31	31.51	3.32	97.8, 110.82	63.93	83.06	104.31	125.56	144.69
NEME_R2 (sec)	104.61	32.25	3.39	97.97, 111.25	63.27	82.86	104.61	126.36	145.94

SD: Standard deviation; SE: Standard error; CI: confidence interval; NFME: Neck flexion muscle endurance; NEME: Neck extension muscle endurance; N: Number of participants.

TABLE 2. Reliability statistics for neck flexion and extension muscle endurance (N = 90).

	$ICC_{2,1}$ (95% CI)	SEM	MDC
Intrarater reliability			
NFME	0.91 (0.86–0.94)	16.54	45.84
NEME	0.90 (0.85–0.93)	17.43	48.31
Interrater reliability			
NFME_R1 (sec)	0.92 (0.88–0.95)	N/A	N/A
NFME_R2 (sec)	0.91 (0.86–0.94)	N/A	N/A
NEME_R1 (sec)	0.94 (0.91–0.96)	N/A	N/A
NEME_R2 (sec)	0.94 (0.90–0.96)	N/A	N/A

NFME: Neck flexion muscle endurance; NEME: Neck extension muscle endurance; N: Number of participants; $ICC_{2,1}$: Intraclass correlation coefficient (model 2, single rater); CI: Confidence interval; SEM: Standard Error of Measurement; MDC: Minimal Detectable Change; N/A: Not applicable.

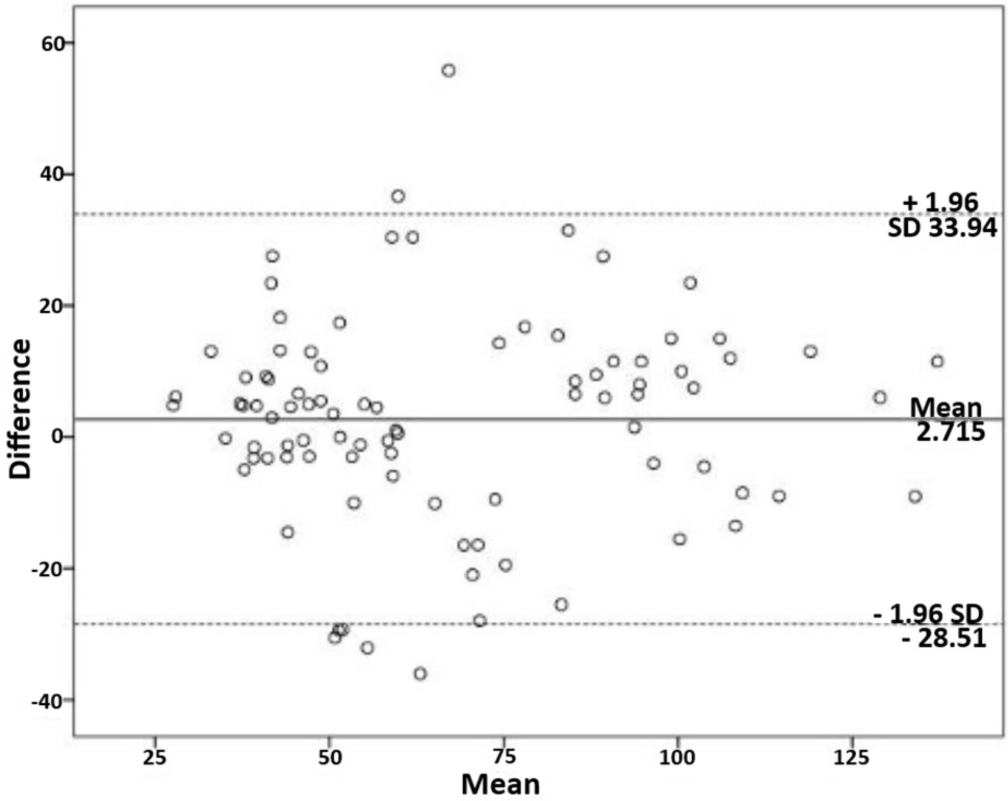

FIGURE 3. Bland-Altman plot for interrater agreement of neck flexor muscle endurance. SD: Standard deviation.

4. Discussion

To the best of our knowledge, this is the first study to evaluate normative data on the endurance of the neck extensor and flexor muscles in healthy Saudi males. Understanding neck muscle endurance is crucial for effective neck rehabilitation. The primary aim of this study was to determine the average endurance times for the extensor and flexor muscles of the neck in this population. The finding showed that the average hold times for neck flexor muscle endurance were 68.57 seconds (Rater 1) and 65.85 seconds (Rater 2), while the average hold times for neck extensor muscle endurance were 104.31 seconds (Rater 1) and 104.61 seconds (Rater 2).

There have been variations in the reported normative values of neck extensor and flexor muscle endurance in previous studies [18, 22, 26–28]. Edmondston *et al.* [27] and Olson *et al.* [26] conducted a study on Australian and the American population, respectively, reporting relatively lower neck flexor muscle endurance values of 36 seconds and 21.14 seconds. In contrast, Harris *et al.* [18] and Painkra *et al.* [28] who studied US-Army personnel and the Indian population, respectively, reported slightly higher neck flexor muscle endurance values of 44 seconds and 51.08 seconds. The highest value was reported by Peolsson *et al.* [22], who studied the Swedish population and found an average neck flexor muscle endurance of 153 seconds. The differences in neck flexor muscle endurance reported in these studies can be attributed to various factors.

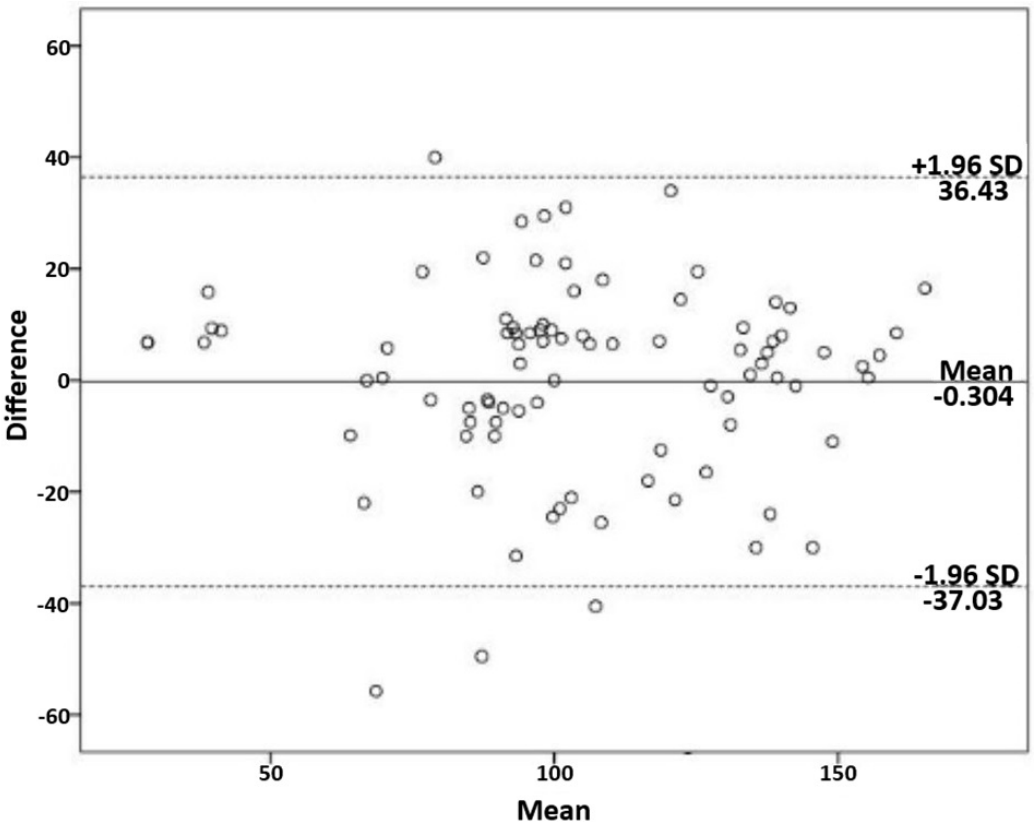

FIGURE 4. Bland-Altman plot for interrater agreement of neck extensor muscle endurance. SD: Standard deviation.

For example, Edmondston *et al.* [27] included only Australian female participants with a small sample size of 12. Peolsson *et al.* [22] studied a larger group (n = 440) with a wide age range (25–62 years) in the Swedish population. However, in this study, we examined a modest sample of 90 Saudi males aged 18 to 37 years.

Only two studies have been published on neck extensor muscle endurance [22, 27]. The average endurance times for neck extensor muscles reported by Edmondston *et al.* [27] and Peolsson *et al.* [22] were 228 seconds and 461 seconds, respectively. In comparison, the current study reported slightly lower neck extensor muscle endurance. Methodological differences, lifestyle factors, population origins and variations in body types across these studies likely contributed to the observed differences in neck extensor muscle endurance.

Smaller sample sizes, like the 12 participants in a previous study [27], increase the risk of statistical error and limit the generalizability of findings. In contrast, the current study's moderate sample size of 90 participants allows for more robust conclusions, though it still lacks the statistical power of studies with larger cohorts. Moreover, the focus on female participants in Edmondston *et al.* [27], introduces gender-specific physiological factors, such as differences in muscle composition and hormonal influences, which limit the applicability of their results to mixed-gender populations. Studies with broader participant profiles provide a more representative view of muscle endurance. However, a narrower age range, as in the current study, allows for precise comparisons within a specific demographic but may fail to capture broader age-related trends [22]. Cultural factors, such as daily activities, physical labor, and exercise habits, also play a critical role in determining baseline muscle endurance [29, 30]. Populations with more physically demanding lifestyles often demonstrate higher neck extensor endurance compared to sedentary groups, while differences in postural habits, such as sitting positions, neck usage, or sleeping patterns, further contribute to variations in results across studies [29, 31, 32].

In the current study, the interrater reliability for both flexor and extensor muscle endurance was rated as good to excellent. Previous studies have reported moderate to good interrater reliability for neck flexor muscle endurance [18, 28]. Other studies found fair to good interrater reliability for neck flexor muscles endurance [16, 19]; however, the confidence interval in these studies were notably wide (*e.g.*, ICC = 0.24–0.85 in Jarman *et al.* [19] and ICC = 0.34–0.86 in Kocur *et al.* [16], which reduces the validity of the results. In contrast, another study reported good interrater reliability for neck extensor muscle endurance [33], but a direct comparison with the current study is not possible as the former study included participants with NP.

The clinical relevance of the SEM and MDC values for neck flexion and extension muscle endurance underscores their importance in interpreting and applying measurement results [5]. In the present study, the SEM and MDC for neck flexor muscle endurance were 16.54 seconds and 45.84 seconds, respectively. Similarly, Juul *et al.* [34] reported comparable values of 16.35 seconds (SEM) and 45.34 seconds (MDC). For neck extensor muscle endurance, the SEM and MDC in this study were 17.43 seconds and 48.31 seconds, respectively, while Juul *et al.* [34] reported slightly higher values of 20.68

seconds (SEM) and 57.31 seconds (MDC).

The findings of this study contribute significantly to establishing normative data by providing endurance benchmarks across different performance levels (*e.g.*, moderate, high). The close agreement between raters' percentiles further emphasizes the reliability of the measurement protocol. However, slight variations between raters highlight the need for standardized training and consistent methodologies to enhance data precision. Overall, these normative values serve as a reliable baseline for evaluating neck muscle endurance in both clinical and research settings, ensuring culturally and contextually relevant assessments.

Despite the study's valuable outcomes, several limitations should be noted. First, the sample was restricted to healthy Saudi males aged 18–37 years, all of whom were university staff or students. This limits the generalizability of the findings to other populations, such as females, older adults, or individuals from diverse socio-economic backgrounds. Second, the exclusion criteria, which ruled out participants with any history of neck pain, musculoskeletal disorders, or other health conditions, further reduce the applicability of the results to individuals with varying health statuses. Additionally, the exclusion of participants with diabetes mellitus—given its known effects on muscle strength and endurance limits the relevance of these findings to populations that include individuals with diabetes. Future research should aim to include a more diverse population, encompassing individuals with chronic conditions. This would provide a more comprehensive understanding of neck muscle endurance across different health statuses and demographics.

5. Conclusions

This study establishes normative data for neck flexor and extensor muscle endurance for healthy Saudi males, demonstrating good to excellent interrater and intrarater reliability. These benchmarks provide a solid foundation for evaluating neck muscle function. Clinically, they facilitate accurate monitoring of endurance changes, guiding tailored interventions to prevent or manage neck pain and muscles weakness, especially in culturally specific contexts. The clinical relevance of the SEM and MDC values for neck flexion and extension muscle endurance underscores their importance in interpreting and applying measurement results. The categorized percentile values offer a clear understanding of the upper ranges of neck muscle endurance in healthy Saudi males, highlighting expected performance in the population. This data-driven approach enables healthcare providers to evaluate, treat and monitor musculoskeletal health effectively, ensuring that clinical decisions are both personalized and evidence-based.

Moreover, these findings can inform global comparative studies, emphasizing the influence of cultural practices on musculoskeletal health and promoting the development of more inclusive health guidelines and preventive strategies. It will also serve as a foundation for further research into neck pain prevention and management, bridging the gap between universal health approaches and region-specific needs.

AVAILABILITY OF DATA AND MATERIALS

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

AUTHOR CONTRIBUTIONS

AHA, HZ, TA, FA and AI—made substantial contribution to study conception and design; critically revised the manuscript for important intellectual content. TA, FA and AI—acquisition of data. AHA, HZ and AI—analysis and interpretation of data. AHA, TA, FA and AI—been involved in the initial drafting of the manuscript. AHA—Supervision. All authors read, understood, and approved the final manuscript version to be published and agreed to be accountable for all aspect of the work were appropriately investigated and resolve.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The study was performed between January and July 2019. According to the ethical guidelines of the 1975 Declaration of Helsinki, the study protocol was reviewed and approved by the Ethics Sub-Committee, King Saud University, Kingdom of Saudi Arabia, under File ID: RRC-2018-002 dated 05 February 2018. Before data collection, written informed consent was obtained from all participating patients as a proof of consent-to-participate in this study.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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