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ORIGINAL RESEARCH

The impact of different ankle positions on postural balance and weight-bearing distributions during different kneeling positions

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Abstract

The objective of this study is to investigate the variations in weight distribution and balance parameters between the knees when executing different kneeling positions with different ankle conditions. Twenty-eight participants, with a mean age of 23.35 ± 3.29 years, were included in the study. HurSmart balance system (HUR smart balance, HUR, Helsinki, Finland) was used for assessing the static balance and weight distribution characteristics of the knees during four different kneeling positions (Full kneeling with ankle dorsiflexion and plantar flexion, upright kneeling with ankle dorsiflexion and plantar flexion) for 30 seconds. Weight distribution on both the dominant and non-dominant knees, postural sways in the anteroposterior and mediolateral directions, the sway area within which the center of gravity was maintained for 90% of the time, and the total trace length were collected. Reliability of the testing method was executed. The simple main effects analysis revealed that knee position had a statistically significant effect on trace length, sway area, anteroposterior and mediolateral sway (p<0.01). The trace length and sway area were higher during upright kneeling postures when compared to full kneeling position. The different ankle positions did not show a significant effect on the balance and weight distribution parameters (p>0.05). This study demonstrates that balance and weight distribution parameters differ significantly across various kneeling positions in healthy individuals. The findings regarding balance and weight distribution in this study could be valuable for clinicians in evaluating different kneeling abilities among individuals.

Introduction

Kneeling is characterized by the placement of both knees on the ground with the applied force, which holds importance across a spectrum of essential daily activities and cultural, religious, and occupational tasks (Amin et al., 2020b). It is known that repetitive kneeling with high knee flexion angles may lead to various degenerative knee problems due to asymmetric and biomechanical loading (Coggon et al., 2000; Haj-Mirzaian et al., 2021). As degeneration progress, individuals gradually lose their kneeling ability due to increased pain and decreased range of motion caused by pain (Kocak et al., 2009). The capability to kneel is widely recognized as paramount for everyday activities and plays a crucial role in facilitating functional recovery following knee surgeries (Amin et al., 2020a). Therefore, understanding the patterns and characteristics of kneeling can serve as a crucial standard for assessing potential knee problems, particularly post-surgical outcomes, given its pivotal role in determining the level of success achieved.

Most researchers have utilized patient-reported outcome measures and various Likert-type rating scales to assess kneeling functions (Artz et al., 2015; Hassaballa et al., 2003; Scott et al., 2021). These outcome measures are assessed kneeling ability with one or two questions, often inquiring whether patients can kneel and subsequently rise. These measures remain incapable in adequately capturing the kneeling ability during the act of kneeling due to different types of kneeling patterns such as full-kneeling, upright kneeling or getting down on one knee. In addition, existing literature evaluating kneeling ability on force platforms (MacDonald et al., 2021; Thwaites et al., 2022) are both

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very few in numbers and not clinically accessible to every clinician and researchers. Asymmetric loading on the knees during kneeling can lead to different postural sways and may result in musculoskeletal problems in the lower extremities in the future. Therefore, there exists a necessity for a comprehensive quantitative outcome measure capable of assessing kneeling capability encompassing factors such as balance across varying kneeling postures and the allocation of weight distribution on the knees.

In this study aimed to investigate the impact of kneeling ability on balance parameters and weight distributions across the knee in varying kneeling positions (full kneeling versus upright kneeling) and under different ankle conditions (dorsiflexion versus plantarflexion). By exploring these factors, the study seeks to enhance our understanding of the kneeling biomechanics considering the ankle positions and provide valuable insights for optimizing assessment techniques and potential interventions for individuals engaging in kneeling activities. It was hypothesized that different kneeling and ankle conditions would have affect the balance and weight distribution characteristics on the knees of healthy participants' kneeling ability. Furthermore, different from the previous studies using force platforms, our study utilized a more cost-effective device for assessing postural stability and weight distributions during kneeling. Thus, another objective was to evaluate the intra-rater reliability of this assessment method.

Methods

Study Design

A cross-sectional study design was used to describe the balance and weight distribution characteristics on the knee in different kneeling positions with different ankle conditions. This research was approved by Hacettepe University Clinical Research Ethics Committee with the number of GO 22/124, and all participants signed consent forms before participating in the study. The study also was registered at ClinicalTrials.gov with the number NCT05678842. The study procedures were conducted in accordance with the Declaration of Helsinki.

Research planning involved a power analysis using the G*Power software (Version 3.0.10, Franz Faul, Universität Kiel, Germany) to determine the required sample size. It was determined that at least 28 participants would be needed to achieve 85% power. A total of 28 participants, with a mean age of 23.35 ± 3.29 years, were included in the study. Inclusion criteria were defined as being between 18-30 years and not having knee pain during kneeling. Exclusion criteria were previous history of lower limb pain/pathology, trauma, and/or surgery, any neurological, rheumatological, or oncological disorders that would affect balance, having performed high-intensity physical activities last 72 hours before test day, and BMI > 25 kg/cm^2. All evaluations were made by two physiotherapists with 8 years of experience in the field (F.Ö and E.Ü).

Kneeling Test Protocol

HurSmart balance system (HUR smart balance, HUR, Helsinki, Finland) was used for assessing the static balance and weight distribution characteristics of the knees during kneeling (Granacher et al., 2011). During the testing, it was required that the knees have full contact with the ground in all positions on the balance system. A soft pad was placed underneath to prevent knee pain and discomfort during the assessment. The assessment involved four specific test positions, which were as follows: full kneeling with ankle dorsiflexion and plantar flexion, and upright kneeling with ankle dorsiflexion and plantar flexion. Each participant received specific instructions for performing each of the four kneeling positions for 30 seconds. They were asked to repeat each position three times until they were satisfied with their execution. A higher score indicates poorer balance control.

The four distinct positions for the assessment were as follows:

Full kneeling with ankle dorsiflexion: Participants were instructed to look forward with the palmar side of the toes in contact with the ground, while the ankle was in dorsiflexion. The knee contacted the ground with full knee and hip flexion, trunk extended, hands beside the body (Figure 1A).

Full kneeling with ankle plantar flexion: Participants were asked to look forward with the dorsum of the foot in contact with the ground, while the ankle was in plantar flexion. Similar to the first position, the knee contacted the ground with full knee and hip flexion, trunk extended, hands beside the body (Figure 1B).

Upright kneeling with ankle dorsiflexion: In this position, participants were instructed to look forward with the palmar side of the toes in contact with the ground, while the ankle was in dorsiflexion. The knee contacted the ground with 90° of flexion, and both hip and trunk were extended. Participants kept their hands beside the body and maintained this position statically (Figure 1C).

Upright kneeling with ankle plantar flexion: Participants were asked to look forward with the ankle in plantar flexion and the dorsum of the foot in contact with the ground. Similar to the third position, the knee contacted the ground with 90° of flexion, and both hip and trunk were extended. Participants kept their hands beside the body and maintained this position statically (Figure 1D).

The measurements collected during the assessments were as follows: weight distribution on both the dominant and non-dominant knees, postural sways in the anteroposterior (AP) and mediolateral (ML) directions, the area within which the center of gravity was maintained for 90% of the time (C90 area), and the total trace length. A two-minute rest period was provided between each test position to minimize discomfort and ensure accurate measurements.

Reliability Tests

To evaluate the reliability of the testing method, the kneeling assessments were executed through three repetitions on different test positions, with a week-long interval between each session. Within each kneeling position, three trials were undertaken, with a resting period of one minute between successive attempts. The sequence of trials was randomized employing a numerical randomization algorithm. The entire set of trials was administered during a single session for each participant. Uniformity was maintained by ensuring that all participants underwent the tests in the morning, thereby minimizing the potential impact of fatigue.

Statistical Analyses

Statistical Package for the Social Sciences (SPSS) (IBM Corp. Armonk, New York, USA) 23.0 program was used for statistical analysis of the data. Measurements were expressed as determined variables and mean ± standard deviation (Mean±SD), and percentage (%) were calculated for variables determined by counting. Normal distribution of data after obtaining visual (histogram) and analytical (Shapiro-Wilk) methods were used to evaluate the data. A two-way between group ANOVA [2 (knee position: full-kneeling, half-kneeling) x 2 (ankle positions: dorsiflexion, plantarflexion)] was conducted to examine differences in balance and weight distribution parameters. In cases where significant differences were observed between knee positions or ankle positions, independent t-tests were performed. Intra-rater reliability was evaluated using the intraclass correlation coefficient (ICC). Minimal change (Minimal Detectable Change, MDC) and measurement standard errors (Standard Error of Measurement, SEM) for kneeling positions specific to each test were calculated and differences were interpreted for the Hur Smart Balance.

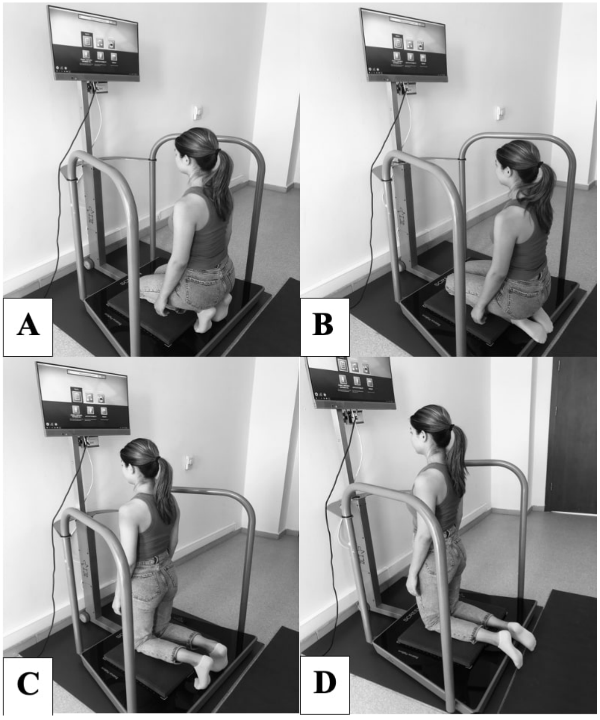

Figure 1. Illustrations of the four kneeling positions used in the study.

Measurement errors of full kneeling and upright kneeling test positions during plantar flexion and dorsiflexion were detected with SEM and MDC with 90% confidence: $SEM=SD \times \sqrt{(1-ICC)}$, $(MDC\ 90\%) = (MDC= 1.96 \times \sqrt{(2 \times SEM)}$ formulas. ICC, SEM, and MDC values of full kneeling and upright kneeling test positions during plantar flexion and dorsiflexion were calculated with the abovementioned formulas. All statistics took the probability of error value as $p<0.05$.

ICC scores, standard error of measurements, and minimal detectable changes were calculated for all positions. Based on the 95% confidence interval of the ICC estimate, values less than 0.50, between 0.50 and 0.75, between 0.75 and 0.90, and greater than 0.90 indicate poor, moderate, good, and excellent reliability, respectively (Koo & Li, 2016).

Results

The descriptive characteristics of participants are presented in Table 1. The right lower extremity exhibited dominance across all individuals.

Balance and Weight Distribution Results

Table 2 represents a comprehensive summary of the various balance parameters and weight distribution measurements. The results of the two-way ANOVA tests indicated that there were no statistically significant interactions between the effects of knee position and ankle position on the balance and weight distribution parameters (Table 3). The simple main effects analysis revealed that knee position had a statistically significant effect on trace length, C90 area (sway area), anteroposterior sway, and mediolateral sway ($p<0.01$). The trace length and C90 area demonstrated elevated values in upright kneeling postures as compared to full kneeling positions. The trace length reached its peak in the context of upright kneeling with dorsiflexion (160.51 mm), while the C90 area exhibited its greatest magnitude in the case of upright kneeling with plantar flexion (68.61 mm^2). The AP and ML sways exhibited greater amplitudes during full kneeling positions in contrast to upright kneeling. The AP sway and ML sway attained their peak values in the context of full kneeling with plantar flexion, registering measurements of 145.46 mm and 12.45 mm, respectively.

Table 1

Demographic characteristic of the participants (Mean ± SD.

	Women (n=20)	Men (n=8)	Total (n=28)
Age (years)	22.70 ± 2.65	25 ± 4.27	23.35 ± 3.29
Height (cm)	162.90 ± 7.21	175.87 ± 6.12	166.60 ± 9.05
Weight (kg)	55.35 ± 7.45	70.75 ± 11.28	59.75 ± 11.06
BMI (kg/m^2)	20.82 ± 2.38	22.76 ± 2.44	21.37 ± 2.52

BMI: Body mass index, kg: kilogram, cm: centimeter, m: meter.

Table 2

Balance and weight distribution values for different kneeling conditions.

		Trace Length (mm)	C90 area (mm^2)	ML Sway (mm)	AP Sway (mm)	WD Left (%)	WD Right (%)
	Ankle	Mean (95% CI LB-UB)	Mean (95% CI LB-UB)	Mean (95% CI LB-UB)	Mean (95% CI LB-UB)	Mean (95% CI LB-UB)	Mean (95% CI LB-UB)
Full kneeling	PF (n=28)	80.45 (64.03-95.98) ‡	20.35 (0.70-40.00) ‡	12.45 (10.31-14.61)	145.46 (133.74-157.20) †	50.96 (50.49-51.43)	49.04 (48.44-49.63)
	DF (n=28)	97.16 (81.64-112.69) ‡	44.02 (24.37-63.67)	11.05 (8.91-13.21) ‡	135.38 (123.65-147.12) †	50.90 (50.44-51.39)	49.30 (48.71-49.90)
	Total n=56)	88.81 (77.83-99.80)	32.18 (18.29-46.08)	11.76 (10.24-13.28)	140.43 (132.13-148.72)	50.93 (50.60-51.27)	49.17 (48.75-49.59)
Upright kneeling	PF (n=28)	156.85 (141.33-172.38) ‡	69.72 (50.08-89.38) ‡	7.53 (5.39-9.88)	60.49 (48.76-72.23) †	50.63 (50.16-51.10)	49.36 (48.78-49.96)
	DF (n=28)	158.17 (142.65-173.70) ‡	74.09 (54.44-93.74)	7.57 (5.42-9.72) ‡	60.72 (48.99-72.45) †	50.66 (50.19-51.13)	49.55 (48.96-50.15)
	Total (n=56)	157.51 (146.54-168.50)	71.91 (58.02-85.80)	7.55 (6.03-9.08)	60.61 (52.31-68.90)	50.65 (50.31-50.99)	49.46 (49.04-49.88)
Total	PF (n=56)	118.65 (107.67-129.63)	45.04 (31.15-58.93)	9.99 (8.48-11.52)	102.98 (94.68-111.28)	50.80 (50.46-51.13)	49.20 (48.78-49.62)
	DF (n=56)	127.67 (116.70-138.65)	59.06 (45.16-72.95)	9.31 (7.80-10.84)	98.05 (89.76-106.35)	50.78 (50.45-51.12)	49.43 (49.01-49.85)
	Total (n=112)	123.16 (53.82)	52.04 (56.11)	9.65 (6.06)	100.51 (50.73)	50.79 (1.25)	49.31 (1.57)

Independent t-tests

PF: Plantar flexion, DF: Dorsi flexion, AP: Antero-posterior, ML: Medio-lateral, WD: Weight distribution, CI: Confidence interval, LB: Lower bound, UB: Upper bound, mm: millimeter.

‡: Difference exists between full kneeling and upright kneeling for the stated parameter, p<0.001.

†: Difference exists between full kneeling and upright kneeling for the stated parameter, p<0.05.

Table 3
The effects of knee and ankle positions on weight distribution and balance parameters.

		Knee Effect	Ankle Effect	Knee*Ankle Interaction
Trace Length (mm)	F	76.947	1.327	$0.965_{(1,108)}$
	p	<0.001	0.252	0.328
	η^2	0.416	0.012	0.009
C90 area (mm^2)	F	16.058	2.000	$0.948_{(1,108)}$
	p	<0.001	0.160	0.332
	η^2	0.129	0.018	0.009
Medio-Lateral Sway (mm)	F	15.009	0.395	$0.438_{(1,108)}$
	p	<0.001	0.531	0.509
	η^2	0.122	0.004	0.004
Antero-posterior Sway (mm)	F	181.841	0.694	$0.759_{(1,108)}$
	p	<0.001	0.407	0.386
	η^2	0.627	0.006	0.007
Weight Distribution Left (%)	F	1.476	0.003	$0.030_{(1,108)}$
	p	0.227	0.960	0.863
	η^2	0.013	<0.001	<0.001
Weight Distribution Right (%)	F	0.935	0.547	$0.019_{(1,108)}$
	p	0.336	0.450	0.891
	η^2	0.009	0.005	<0.001

Two-way between group ANOVA; mm: Millimeter.

Table 4
ICC, standard error of measurement and minimal detectable change scores of the subjects (n=28).

Variables		Full Kneeling Plantar Flexed	Full Kneeling Dorsiflexed	Upright Kneeling Plantar Flexed	Upright-Kneeling Dorsiflexed
Trace Length (mm)	ICC	0.79	0.81	0.70	0.83
	SEM	16.10	18.90	22.42	18.01
	MDC	11.12	12.05	13.12	11.76
C90area (mm^2)	ICC	0.75	0.61	0.65	0.75
	SEM	11.64	40.92	30.94	19.91
	MDC	9.45	17.73	15.41	12.36
Medio-Lateral Sway (mm)	ICC	0.81	0.69	0.83	0.89
	SEM	5.07	5.72	3.19	2.51
	MDC	6.24	6.62	1.4	4.39
Antero-posterior Sway (mm)	ICC	0.95	0.87	0.33	0.34
	SEM	7.48	5.45	19.39	4.98
	MDC	7.58	6.47	12.20	6.18
Weight Distribution Right (%)	ICC	0.81	0.54	0.82	0.89
	SEM	0.67	1.25	0.45	0.35
	MDC	2.26	3.09	1.85	1.63
Weight Distribution Left (%)	ICC	0.81	0.64	0.82	0.89
	SEM	0.67	0.74	0.45	0.35
	MDC	2.26	2.38	1.85	1.63

ICC: Intraclass correlation coefficient; SEM: Standard Error of Measurement; MDC: Minimal Detectable Change.

The allocation of weight distribution to the non-dominant knee ranged between 50.66% and 50.96%, greater than the distribution to the dominant knee, which ranged between 49.03% and 49.33%.

The ankle position did not show a significant effect on the balance and weight distribution parameters, as indicated by the simple main effects analysis (p>0.05).

Results of the Testing Protocol's Intrarater Reliability

All ICC scores, SEM and MDC values were given in Table 4 for each kneeling position. Although, AP sway showed excellent reliability in full kneeling and plantar flexed position, ICC scores were poor in upright kneeling positions regardless of ankle position. Reliability of C90area, ML sway, and weight distributions in full kneeling with ankles in dorsiflexion, and trace length and C90area in upright kneeling with ankles in plantar flexion were moderate. All other ICC scores had good reliability.

Discussions

This study aimed to investigate the effect of kneeling ability on different balance parameters (C90 area, AP and ML postural sway, and trace length) and weight distributions on the knee in different kneeling positions (full kneeling and upright kneeling) with different ankle conditions (dorsiflexion and plantar flexion). The results showed that ankle positions did not lead to significant differences in balance parameters or weight distribution to the knees during both kneeling positions. However, differences in balance parameters were observed among the different kneeling positions with the same ankle positions. As a result, the hypothesis was accepted partially, while ankle positions did not have a significant effect on the balance parameters; notable effects were observed in different kneeling positions. Also, the assessment method used in this study might be considered an easy and reliable method to assess kneeling ability.

The results of the present study revealed that the alterations in ankle positions did not yield a notable impact on postural sways, encompassing both movements in the AP and ML directions, across both full and upright kneeling stances. Nonetheless, postural sway did exhibit variation with distinct knee positions, although with a consistent ankle position maintained (either in plantar flexion or dorsiflexion). This observation underscores the influence of knee posture on postural sway while accounting for a fixed ankle position. Interestingly, the study found that there was less postural sway in the upright kneeling position (with 90° knee flexion) compared to the full kneeling position (with greater than 110° knee flexion). This difference in postural sway could be attributed to the fact that the upright kneeling position is generally more tolerable for both symptomatic and asymptomatic knees, as supported by previous research (Calvert et al., 2019). Mezzarane et al. conducted a study investigating the disparities in postural control between kneeling with 90° knee flexion and upright standing positions (Mezzarane & Kohn, 2008). Their findings revealed that the full kneeling position exhibited faster postural oscillations compared to the upright standing position. Likewise, Pollard et al. reported a higher AP and ML postural sway velocity during nearly full flexion kneeling when compared to various squatting positions, kneeling at approximately 90 degrees knee flexion, and kneeling with one knee (Pollard et al., 2011). Additionally, present research evaluated the trace length, which represents the length of the center of mass motion during testing. The present study results revealed that difference was observed only when the knee position was changed, and the trace length was found to be greater in the upright kneeling positions compared to the full kneeling positions. These results can be attributed to the fact that the center of gravity is higher in the upright kneeling position and the contact to the support surface is reduced in this position. This may affect the muscle activations needed to maintain balance. In the full kneeling position, a larger support area is provided, whereas in the upright kneeling position, more fine motor control and small balance muscles may need to be engaged to maintain balance, as the body is in a more upright position. Despite higher postural sway in full kneeling positions, the sway area (C90 area) and trace length results were lower. The situation that reveals this difference may be due to the velocity difference, but since this data was not collected in our study it is not possible to relate or justify these results to each other. From a biomechanical point of view, in the FK position, a wider support area is provided and knee stabilization comes to the fore, while in the UK position, with a more upright posture, the muscles for pelvis and trunk stability work more effectively. These different positions may have led to activation of different muscle groups to maintain balance.

In this study, the examination of weight distribution in a kneeling position indicated that there was no notable difference in weight distribution between knees, irrespective of limb dominance and ankle conditions, across both kneeling positions. One possible explanation for this finding is that participants did not require additional support from their legs while kneeling, unlike in a standing position. This may be attributed to the fact that both the foot and the knee are in contact with the ground during kneeling, resulting in better stabilization of the hip and trunk. It has been previously reported that approximately 75% of the population prefers to use their dominant lower limb for motor performance, while the non-dominant side plays a stabilizing role during standing activities (Carey et al., 2001; Olex-Zarychta & Raczek, 2008). However, in the context of kneeling, where additional support is provided by the foot and knee, the typical dominance-related differences in weight distribution may not be as prominent. The similar distribution of weight transfer in both the FK and UK positions may indicate that the knee joint and lower leg muscles function sufficiently to ensure stability and that body weight is not loaded on distinctly different muscle groups in both positions. The fact that our participants were healthy young individuals may be the main reason for this. Seeing the results of an adult with knee joint problems would have provided a deeper insight into clinical biomechanical approaches to weight distribution strategies.

MacDonald et al. developed a novel test method to assess anterior knee discomfort during weight-bearing positions on the knees (MacDonald et al., 2021). They conducted evaluations with both healthy population and individuals undergoing tibial nailing surgery. In their research, they investigated the weight-bearing mean ratio (right/left) and reported no significant difference in the distribution of weight through both knees during upright kneeling. Similarly, Thwaites et al. examined the weight-bearing ratio between the right and left knee in a healthy population during upright kneeling (Thwaites et al., 2022). Employing two platforms to measure vertical ground reaction forces, center of pressure, and force-sensitive resistor activations, their findings mirrored ours, revealing no significant differences in the weight-bearing ratio between the right and left knee. The common conclusion of the previous studies was reasonable to infer that in healthy individuals, the distribution of weight applied to the knees while in a kneeling position adheres to a symmetrical pattern.

The findings of the present study revealed a wide range of reliability results in postural sway for both full and upright kneeling positions. The testing protocol performed in various kneeling positions demonstrated moderate to high reliability (ICC scores ranging from 0.61 to 0.95), except for the AP postural sway evaluation in the upright kneeling position, which showed lower reliability (ICC≤0.34). Furthermore, the study also assessed the ICC scores for both full and upright kneeling positions with different ankle positions, and it was observed that the weight distribution ICC scores were better in the upright kneeling positions compared to the full kneeling positions. One possible explanation for this result could be that the different flexion angles of the knee during full kneeling resulted in varying stresses on the knee, making full kneeling positions more uncomfortable for the knees and ankles. Overall, the assessment of weight transfer was highly reliable, except for full kneeling in dorsiflexion. In future studies, balance and weight distribution can be evaluated in full kneeling and upright kneeling positions after knee surgeries. It should also be kept in mind that it may be better to keep the assessment duration shorter (i.e., 10 seconds) to eliminate discomfort that may occur for long periods of kneeling.

The present study has several limitations to acknowledge. The study did not investigate the assessment of participants' kneeling tolerance levels and discomfort experienced in the knee and ankle regions. Kneeling tolerance can indeed vary significantly from person to person, and the presence of discomfort in the knee and ankle joints could potentially exert an influence on balance and weight distribution results, particularly in the context of full kneeling positions. Incorporating an assessment of participants' subjective experiences and comfort levels during kneeling could provide a more holistic understanding of the biomechanics and feasibility of different kneeling postures. Furthermore, it's important to note that the results of this study were derived from a sample of young and healthy individuals. While these findings offer valuable insights into the biomechanics of kneeling in this population, caution should be exercised when generalizing these results to older individuals or those experiencing knee pain or individuals with knee surgery.

The results of the study may help clinicians to understand how postural stability changes under different positions and may guide clinicians in terms of evaluation and rehabilitation. Assessing stability in different positions, especially in patients with knee pain, knee trauma or knee surgery, may facilitate the development of correct treatment strategies and help these patients to increase their postural stability and improve their functional capacity by practicing balance exercises in more stable positions. A more dynamic approach can be adopted in the assessment of postural stability and the effectiveness of treatment plans can be evaluated by monitoring the balance between different positions in patients with knee joint problems, and the treatment process can be improved by adding special exercises if necessary. Subsequent investigations could explore the weight distribution and balance performance across various kneeling positions within distinct age groups and among individuals experiencing knee pain. This avenue of research has the potential to yield valuable insights into how age-related factors and knee pain might interact with different kneeling postures. Studying how weight distribution and balance vary in different age categories could help unravel the impact of physiological changes associated with aging on kneeling ability. Additionally, considering individuals with knee pain could provide a deeper understanding of how existing discomfort might influence balance and weight distribution during kneeling activities.

Conclusions

The study's results indicate that ankle positions (dorsiflexion versus plantarflexion) did not have a significant effect on balance parameters during both full and upright kneeling positions. However, the kneeling positions with the same ankle conditions did affect the balance parameters, suggesting that the specific kneeling posture plays a role in balancing ability. Furthermore, the weight distribution to the knees remained similar in different kneeling positions for both ankle conditions, indicating that neither ankle position nor different kneeling postures and even limb dominance significantly affected weight distribution to the knees during kneeling. These findings have potential clinical implications, as they can help clinicians better understand and assess different kneeling abilities in individuals. Moreover, the study's novelty lies in being the first to investigate the effect of different kneeling positions and ankle conditions on balance and weight distribution to the knees, providing a foundation for future research in this area. Also, the assessment method used in the current study can be applicable/adaptable to the devices that providing similar data and can be studied further. Overall, the study's results contribute valuable insights into the biomechanics of kneeling and can be utilized by clinicians and researchers alike to enhance their understanding and evaluation of kneeling abilities and associated weight distribution to the knees.

Authors' Contribution

Conceptualization: FÖ, SBB, GAB, HGD; Data Curation: FÖ, FT, EÜ, SBB, Data Analysis: GAB, GİK; Supervision: SBB, GİK, HGD; Writing: FÖ, EÜ, GAB, FT; Writing Review and Editing: SBB, GİK, HGD.

Declaration of Interest Statement

The authors report there are no competing interests to declare.

Ethical Approval

Hacettepe University Clinical Research Ethics Committee (GO 22/124).

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