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Analysis of functional prorpioception in lower limb among younger and older adults

Analiza funkcjonalnej propriocepcji kończyny dolnej wśród młodszych i starszych dorosłych

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Abstract

Background. Proprioception is the internal sense that assists an individual in learning a motor task and executing it seamlessly. Generally, a proprioception deficit is tested by measuring degrees of error in repositioning a joint or limb in space. Most of the measures use single-joint movement and, on a few occasions, multi-joint movements are tested with high-tech instrumentation in a laboratory setting. Multi-joint testing can reflect the impact of a proprioception deficit in functional activity. We used a novel method to test proprioception as a functional activity.

Aim. The study aims to analyse the functional proprioception in the lower limbs of younger and older adults.

Methodology. Thirty-seven younger and thirty-seven older adults were tested for proprioception in lower limbs with a target-reaching task. The participant was given a target point to touch with the great toe with eyes open. Following the trial, they were asked to touch the target with their eyes closed. The error in distance was measured in centimetres for three attempts. The minimal error was taken for analysis.

Result. The result shows that a mean error of around 2.6 cm and 5.7 to 6 cm is present in young and older adults respectively. There was no difference with respect to the side noted in the young adults, but the left side of adults shows a marginally higher error compared to the right side.

Conclusion. Functional proprioception differs among young and older adults. Multi-joint proprioception can provide different insights into an individual's ability to use proprioception effectively.

Keywords

proprioception, multi-joint testing, younger adults, older adults

Streszczenie

Tło. Propriocepcja to wewnętrzne wyczucie, które pomaga jednostce w nauce zadania motorycznego i jego bezbłędnym wykonywaniu. Zwykle deficyt propriocepcji jest testowany poprzez mierzenie stopnia błędu w pozycjonowaniu stawu lub kończyny w przestrzeni. Większość pomiarów korzysta z ruchu jednostawowego, a w kilku przypadkach ruchy wielostawowe są testowane za pomocą zaawansowanego sprzętu w warunkach laboratoryjnych. Testowanie wielostawowe może odzwierciedlać wpływ deficytu propriocepcji na aktywność funkcjonalną. Użyliśmy nowatorskiej metody do testowania propriocepcji jako aktywności funkcjonalnej.

Cel. Badanie ma na celu analizę funkcjonalnej propriocepcji w dolnych kończynach młodszych i starszych dorosłych.

Metodologia. Trzydziestu siedmiu młodszych i trzydziestu siedmiu starszych dorosłych zostało przetestowanych pod kątem propriocepcji w dolnych kończynach za pomocą zadania dotyczącego osiągnięcia celu. Uczestnikowi podano punkt docelowy do dotknięcia dużym palcem przy otwartych oczach. Po próbie poproszono ich, aby dotknęli celu z zamkniętymi oczami. Błąd w odległości mierzono w centymetrach w trzech próbach. Minimalny błąd został uwzględniony w analizie.

Wynik. Wyniki pokazują, że średni błąd wynosi około 2,6 cm dla młodszych dorosłych oraz od 5,7 do 6 cm dla starszych dorosłych. Nie stwierdzono różnicy względem strony w grupie młodszych dorosłych, ale lewa strona u dorosłych wykazywała nieznacznie wyższy błąd w porównaniu do prawej strony.

Wnioski. Funkcjonalna propriocepcja różni się między młodszymi a starszymi dorosłymi. Wielostawowa propriocepcja może dostarczyć różnych spostrzeżeń na temat zdolności jednostki do skutecznego wykorzystania propriocepcji.

Słowa kluczowe

propriocepcja, testowanie wielostawowe, młodsi dorośli, starsi dorośli

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Introduction

Proprioception defines the sense of position and action of the limbs. Proprioception can be considered as one of the subsystems within the somatosensory system which includes sensory information from internal structures[1]. Three testing techniques were commonly used for assessing proprioception: the threshold to detection of passive motion (TTDPM), joint position reproduction (JPR), also known as joint position, and active movement extent discrimination assessment (AMEDA)[1, 2].

Single-joint is tested in proprioception assessments rather than the whole limb. As proprioception is a contributor to movement planning and movement execution, testing a whole limb movement is more likely to reflect the impact of the proprioceptive deficit on functional movement than a single joint assessment. Raju and Ramachandran (2018) report that discharges from the brain influence proprioception and mask the deficit while active joint position reproduction is tested[3]. Corollary discharges are based on the brain's programming related to the movements. It can be assumed that a learned functional movement, as in the case of reaching a known target in a known environment, is likely to be influenced by these corollary discharges. An individual reaching a switchboard seamlessly in his/her room when the room is dark could be considered as a learned functional movement where corollary discharges and proprioception play a role. Thus, testing multi-joint proprioception could provide insight into an individual's ability to compensate for a deficit or the impact of the deficit on functional movement. Few studies have been done using robotics to assess multi-joint proprioception. These studies are predominantly done in distal parts of the limb like the wrist and ankle.

The impact of lower proprioception on everyday life activities includes postural control, walking, and stair climbing in a known environment during dual-task performance.

In day-to-day life without proprioception, we are able to reach footwear without visual feedback if other spatial variables are constant. Aging is associated with numerous changes in the neuromuscular system that are accompanied by a general decline in motor performance, like gait. Understanding this proprioception error may be useful for health education and training purposes.

Aim

The study aims to analyze the functional proprioception in lower limbs among younger and older adults.

Methodology

The study was approved by the Institutional Ethical Committee Sri Ramachandra Institute of Higher Education and Research, Chennai, India[REF: CSP/23/JUN/130/554].

This study was conducted in the Outpatient Department of Physiotherapy. A sample of 37 in each group was arrived at using a priori with the likely difference between young and older groups being 5 cm, effect size of 0.85, α-0.05, and power of 0.95. The difference between the groups was identified by a pilot test among the groups.

The younger adults in the age range of 20 to 24 years were included in the study and those with knee pain, and limb length discrepancy were excluded. Older adults in the age range of 60 to 75 years were included in the study, and those with a history of musculoskeletal conditions, history of diabetes, and cognitive impairments that might affect the outcome of the study were excluded.

Informed consent was obtained from the participants. This study was conducted at a university teaching hospital's physiotherapy outpatient department.

Initially, the subject was made to lie on their back and asked to touch a target point on a sheet placed at their foot end. The target was kept at knee level so that the subject had to bend their hip and knee to touch the target. The target was a dot at the center of a sheet, resembling a zero point on a graph sheet's X and Y axis. The subject was asked to touch the point five times with the great toe of the right leg. After five trials, the subject was asked to close their eyes and repeat an attempt to touch the target point. Before the attempts, a red ink dye was applied to the great toe of the subject.

The points the subject contacted on the paper were noted with the dye marks. The subject was asked to repeat three times. The same procedure was repeated with the left leg, starting with the subject touching the target with eyes open five times, followed by eyes closed with red dye on their great toe.

The difference in distance from the zero point of the target and the subject's contact point was measured in a straight line in centimeters. The quadrant in which the subject made contact was also noted. The minimum error distance of the three attempts was used for analysis. The data was analyzed with student's t-tests within young and older adults and between the young and older adults. The difference between the sides was tested among the group and between the groups.

Figure 1.Participant positioning and reaching the target point

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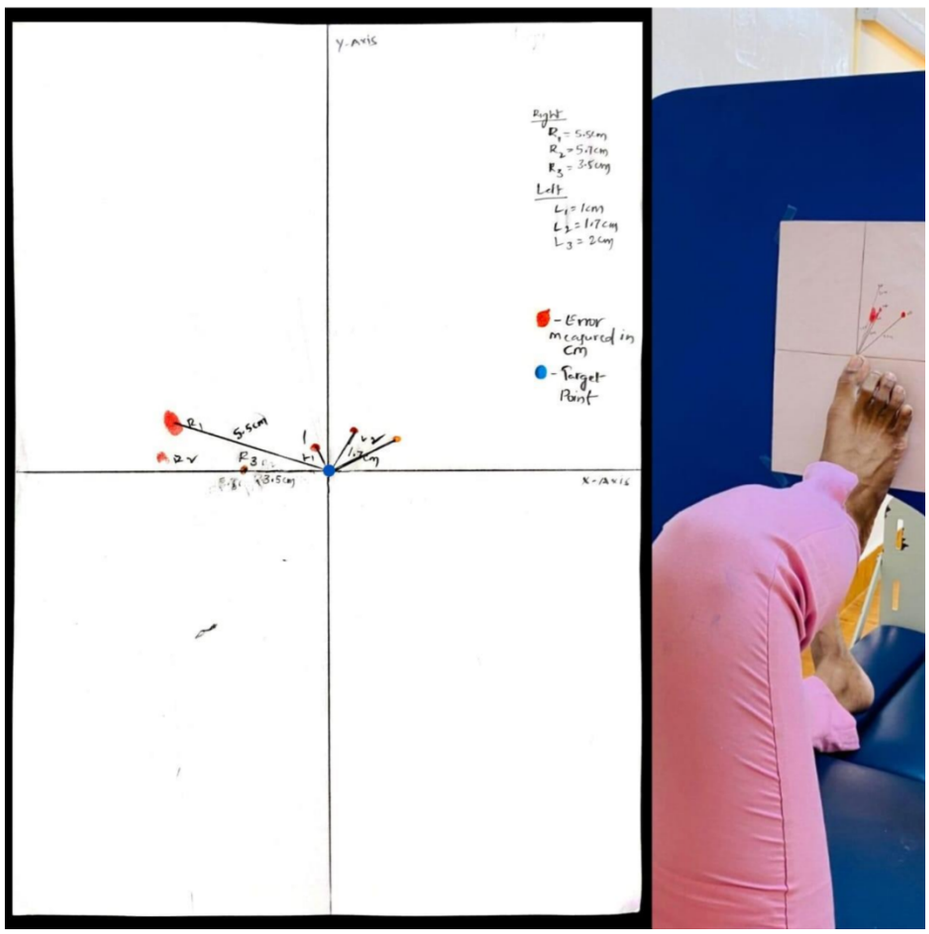

Figure 2. Target point (Blue dot) and participant's contact point for error measurement

Results

Table 1.Demographic data

Variables	Younger adults (n = 37)	Older adults (n = 37)
Age: Mean ± SD	24 ± 0.03	64 ± 0.05
Gender (Male/Female)	25/12	32/5

Table 2. Descriptive analysis between younger and older adults

	Right side error in cm (Mean ± SD)	Left side error in cm (Mean ± SD)	P^a
Younger adults (n = 37)	2.68 ± 1.16	2.68 ± 1.74	0.98
Older adults (n = 37)	5.76 ± 2.76	6.11 ± 2.57	0.57
P^b	<0.001*	<0.001*	

P^a – between sides in younger and older adults; P^b – between right / Left side between younger / older adults
**P ≤ 0.05 Significant; SD – Standard deviation*

The result shows that a mean error of around 2.6 cm and 5.7 to 6 cm is present in young and older adults respectively. There was no difference with respect to the side noted in the young adults, but in the left side of adults, there was a marginally higher error compared to the right side. Older adults have a higher error compared to younger adults. Figure 7 and Figure 8 show the contact points by young and older adults during the three testing movements. This displays the spatial variation demonstrated by the participants. The left was predominantly placed slightly higher than the target in older adults whereas the younger adults placed it lower than the target. The right limb placement was deviated to the left side of the target in young adults, but they were predominantly on the right side in older adults.

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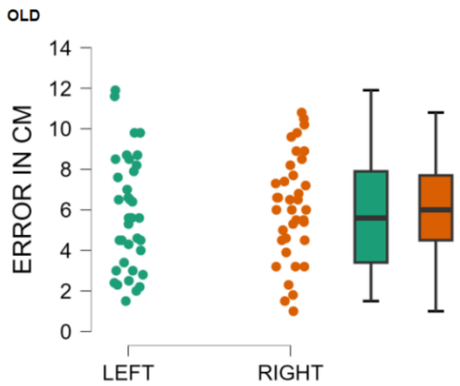

Figure 3. Error distancing between left and right older adults of lower limbs

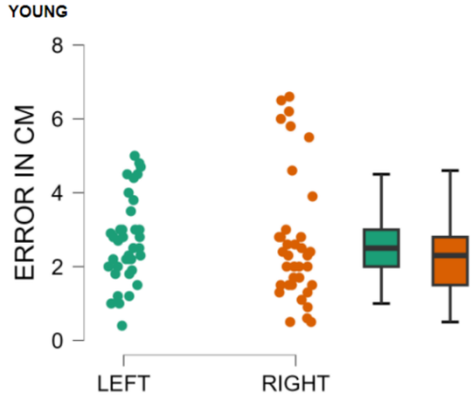

Figure 4. Error distancing between left and right younger adults of lower limb

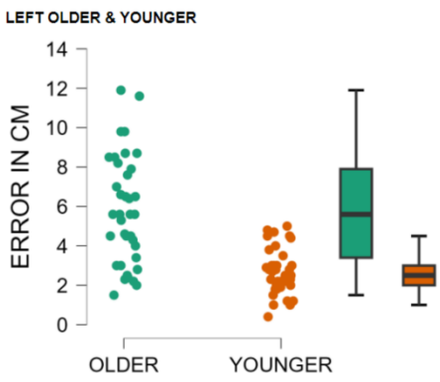

Figure 5. Left Error distancing between older and younger adults for observation

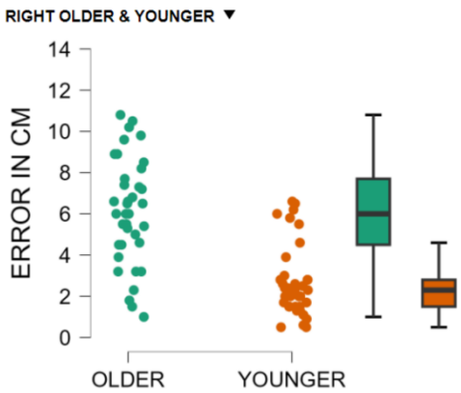

Figure 6. Right Error distancing between older and younger adults for observation

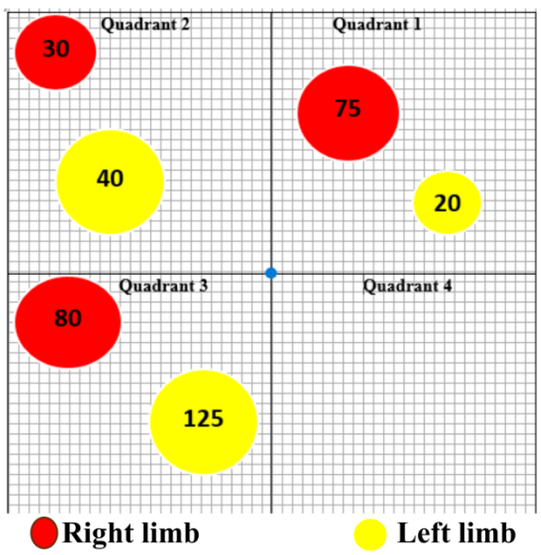

Figure 7. Younger adults' contact points grouped in quadrants of around target point (Blue dot)

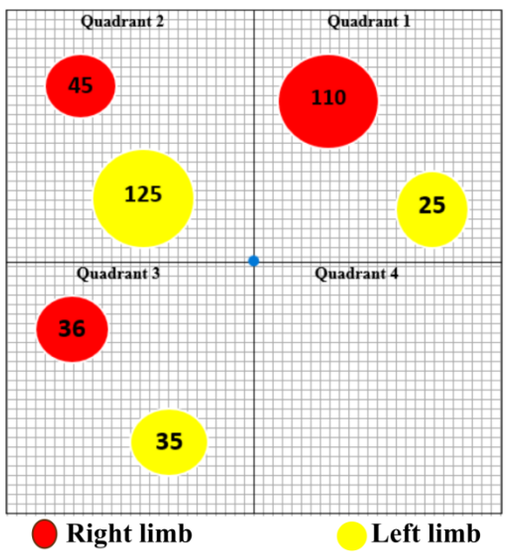

Figure 8. Older adults' contact points grouped in quadrants of around target point (Blue dot)

Discussion

In this study, we found functional proprioception error in both younger and older adults. Similar studies which assess the proprioceptive error with multi-joint movement are hard to find. Proprioception tests are generally passive in nature and are tested with a single joint. Active proprioception tests are also advocated; however, they are still limited to single joint testing[1,2]. Active movement extent discrimination assessment

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(AMEDA) is a method used for assessing the proprioception in a closed kinematic chain, claiming that the assessment is closer to real-life scenarios[4]. The AMEDA testing is predominantly done on the ankle joint[5-8]. Though the testing is done in a closed kinematic chain, the target joint was a single joint, i.e., the ankle joint.

As we observed in a functional task, an individual has to control multiple joint spaces, as in the case of reaching for an object, especially in the absence of a visual cue, proprioception plays a major role. In daily life situations, an individual reaching for targets like switchboards in a dark room will require proprioceptive support to perform the task. In the present study, we recreated a similar situation where the individual has to reach a target with the lower limb with eyes open, and to reach the same target, the individual has to do so with eyes closed. We tested the lower limb as we found errors in such scenarios in the upper limb in our earlier unpublished study.

We found reaching errors in both young and older adults. Older adults had greater error distances than younger adults. Though the testing did not encompass a perfect three-dimensional space in terms of testing, it is suitable to identify errors in the movement's X and Y axis. Few studies have used robotic exoskeletons to assess movement in a three-dimensional space[5,9,10]. The study suggests that such assessments can add value to proprioception testing in terms of quantification. The current study can provide similar improvements in quantification in proprioception without major technological requirements.

We also found error not only in terms of distance from the target but also in the direction away from the target point. This denotes a possible error occurring in the "Z" dimension of the movement plane. The left limb was predominantly on the left side; however, the right limb contacts were shifted to the left side as well, notably in younger adults. The older adults had predominantly contacts at a higher level than the target point. Though we could not provide a physiological explanation for such scenarios, the findings were interesting to note and can be translated into valuable insights for training sessions.

Limitations

The findings were limited to a single-time assessment; repeating the testing over a few more sessions might help in understanding the reproducibility of the result.

Conclusion

Functional proprioception error is found in both young and older adults. The method used in this study could be useful in assessing the proprioception of multi-joint proprioception.

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