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Proprioceptive Training: An Analysis of the term and Its Applicability

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ABSTRACT

Introduction: Proprioception is the sensory ability to perceive body positions without relying on vision. The so-called "Proprioceptive Training" is frequently used in the final phase of physical therapy rehabilitation following traumatic injuries that required prolonged immobilization. However, the adequacy of this terminology is questioned, considering that these exercises involve various body systems beyond proprioception.

Objective: To determine whether the term "Proprioceptive Training" is suitable to describe the exercises currently designated as such, identify possible proprioceptive deficits in knee and/or ankle joints in individuals in the final phase of physical therapy rehabilitation, quantify these deficits and propose an alternative terminology if proprioceptive sensitivity is preserved.

Methods: This observational, analytical and descriptive study evaluated two groups: Healthy Subjects (HS) and individuals in the Final Phase of Physical Therapy Rehabilitation (FPTPR), following immobilization for at least 30 days due to traumatic injuries. The proprioception assessment considered a margin of error of ±3 degrees.

Results: The results showed that the HS group correctly identified 151 (89.88%) positions, while the FPTP group achieved 150 (89.29%) out of a total of 168 possible, with no significant difference between the groups.

Conclusion: No significant proprioceptive deficits were found in the rehabilitation group. Thus, the term "Proprioceptive Training" may be deemed inadequate, suggesting its revision to better reflect the systems involved and therapeutic objectives.

Keywords: Proprioception, Physical therapy rehabilitation, Proprioceptive training

1. Introduction

Introduction proprioception was defined by Sherrington as the set of bodily sensations generated during one's own actions. Initially, it was described as referring to afferent information from peripheral mechanoreceptors, such as muscle spindles and Golgi Tendon Organs (GTOs) originating in joints, tendons and other tissues. This information is sent to the Central Nervous System (CNS) and subsequently redistributed through efferent pathways, influencing reflex responses and voluntary motor control. Additionally, Sherrington suggested its contribution to postural balance, joint stability and muscle sensations[1-3]. Currently, proprioception is defined as the ability to sense and

perceive body positions, including kinesthesia, arth esthesia and pall esthesia, without visual assistance[4]. It is known that proprioception is part of the somatosensory system and is influenced by other systems, structures and functions such as the visual and vestibular systems, muscle tone and strength, joint range of motion, reaction time and pain degree. These factors contribute to balance and postural control, joint stability and various conscious sensations[1-3]. It is essential to understand that proprioception is limited to the acquisition of mechanical stimuli and their transduction into neural stimuli, without directly intervening in CNS processing and motor response[1].

However, these systems and structures may undergo changes after long periods of joint immobilization, such as in cases of post-traumatic injuries to the lower limbs. Among the alterations found are adhesions in connective tissue, cartilage fibrosis and surface issues, cartilage atrophy or blockage, disorganization of ligament cells and fibers, proliferation of fibrous connective tissue within the joint space, weakened ligaments, adhesions between synovial joints, loss of tone, muscle trophism and strength[5,6].

Consequently, "Proprioceptive Training" is frequently employed in the final phase of physical therapy rehabilitation for patients who have suffered traumatic injuries to the knee or ankle and undergone prolonged immobilization. This training aims to strengthen the structures of the affected limb and improve balance and body control through exercises involving equipment such as flat spinners, balance boards, proprioceptive disks, trampolines, Swiss balls, as well as gait training and static balance exercises[7-9].

Nevertheless, it is expected that dysfunctions related to balance and control will have already been resolved by the end of physical therapy rehabilitation[10]. Studies highlight the effectiveness of this training in improving the functions of systems contributing to joint stability, particularly in reducing functional instability after injuries. However, these studies do not include prior evaluations of proprioceptive performance to confirm deficits before applying "Proprioceptive Training." In light of this, the present study aims to achieve greater scientific rigor in the employment of the term "Proprioceptive Training." Given the widespread use of this training in the final phase of rehabilitation for patients with traumatic lower limb injuries and considering that such exercises are applied without proprioceptive evaluation tests and in the absence of nervous system injury, the following question arises: "Is 'Proprioceptive Training' the most appropriate term to describe these exercises as currently defined?"

1.1. Objectives

1.1.1. General objective: To determine whether "Proprioceptive Training" is the most appropriate term to describe the exercises currently designated as such.

1.1.2. Specific objectives: a) To assess the existence of proprioceptive deficits in knee and/or ankle joints during the final phase of physical therapy rehabilitation after prolonged immobilization due to traumatic injury.

- To quantify these deficits.
- To propose a new nomenclature for the exercises if proprioceptive sensitivity is found to be normal.

2. Methodology

2.1. Study design

This is an observational, analytical and descriptive study conducted in Physical Therapy Clinics in the State of Rio de Janeiro between May and October 2021. The project was approved by the Ethics and Research Committee (CEP) of UNIG under the approval number 3.612.708, with CAAE number: 21231419.8.0000.8044).

2.2. Recruitment of participants

The sample consisted of men and women aged between 20 and 45 years, divided into two groups: Healthy Subjects (HS) and individuals in the Final Phase of Physical Therapy Rehabilitation (FFPTR). Each group was further subdivided into two subgroups: one that underwent the Joint Position Reproduction Test (JPRT) for the knee and another for the ankle. Participant recruitment was conducted in Physical Therapy Clinics in the State of Rio de Janeiro. After initial contact, a consultation was scheduled via phone to present the steps of the study.

2.3. Exclusion criteria

Individuals with lesions in the Central or Peripheral Nervous System or any other condition affecting the lower limbs were excluded. Additionally, those who did not agree to sign the Free and Informed Consent Form, which details the experimental conditions, were excluded.

2.4. Inclusion criteria

Participants in the study included individuals who suffered traumatic injuries to the knee or ankle, had been immobilized for at least 30 days, presented a full range of joint motion and had a minimum muscle strength grade of five.

2.5. Proprioceptive Assessment Protocol

Proprioceptive assessment was performed using the Joint Position Reproduction Test (JPRT). The participant was positioned in a lateral decubitus position, with the non-injured side placed on a therapy table and a pillow placed between the lower limbs. Using a digital goniometer (Shahe Instruments & Tools Store China), the examiner passively positioned the joint in predetermined degrees of joint range of motion: for the knee, 45° (flexion), 90° (flexion) and 110° (flexion); and for the ankle, 10° (dorsiflexion), 0° (neutral) and 20° (plantar flexion).

The participant maintained the position for five seconds before returning to the initial position. Then, they were instructed to actively reposition the joint to the same degree without visual assistance. This procedure was repeated four times for each degree of motion. The participant verbalized "here" to indicate the degree they judged correct. Differences greater than 3° between active and passive positioning were considered errors. Participants with more than three errors were classified as having proprioceptive deficits.

2.6. Statistical analysis

Descriptive analyses were performed by counting the correct and incorrect responses in the joint position sense, considering a margin of error of ±3°. Subsequently, the average of the four repetitions in the three joint positions of the knee and the three positions of the ankle were calculated for both groups (HS and FFPTR). The statistical software SPSS version 25 (IBM) was

used to apply the Independent Samples T-Test on these averages, with the goal of comparing the performance of the two groups.

3. Results

This study involved a total of 28 individuals, including 17 women and 11 men, corresponding to 60.71% and 39.29% of the sample, respectively. These participants were divided into four groups, as shown in (Table 1). Among them, 14 belonged to the SS group and 14 to the FFRF group. In the SS subgroup that underwent TRPA applied to the knee, there were 3 men and 2 women, with an average age of 38.2 years, while the FFRF subgroup consisted of 4 men and 1 woman. Conversely, the SS subgroup that underwent TRPA applied to the ankle included 8 women and 1 man, whereas the FFRF subgroup was composed of 6 women and 3 men.

Table 1: Demographic and Anthropometric Profile of the Study Participants.

Group	Women N (%)	Men N (%)	Average Age (years)	Average Weight (kg)	Average Height (cm)	Average BMI (kg/m²)
Knee (FFRF)	1 (20%)	4 (80%)	23	70.8	171.4	23.98
Knee (SS)	2 (40%)	3 (60%)	38.2	83.6	171	28.6
Ankle (FFRF)	8 (66%)	1 (33%)	32.88	73.11	170.33	25.37
Ankle (SS)	6 (88%)	3 (11%)	26.11	66.46	166.44	23.9
Total Average	17 (60%)	11 (39%)	29.82	72.43	169.39	25.22

The results, considering a margin of error of ±3 degrees, indicate that there were no significant differences between the two knee subgroups or between the two ankle subgroups, as demonstrated in (Table 2). The subgroups that performed TRPA on the knee each reproduced 60 joint positions. The SS subgroup achieved 49 correct responses (81.67%), while the FFRF subgroup achieved 52 correct responses (86.67%).

Regarding the joint positions reproduced on the ankle, both subgroups reproduced a total of 108 positions each. The SS subgroup recorded 102 correct responses (94.45%), while the FFRF subgroup achieved 98 correct responses (90.74%).

The comparative analysis of errors revealed that individuals in the SS and FFRF subgroups who performed TRPA on the knee collectively made 19 errors (15.83%) out of 120 reproduced joint positions. Among these, the SS subgroup accounted for 11 errors, corresponding to 18.33% of the reproduced positions, while the FFRF subgroup made 8 errors, representing 13.33% of the reproduced positions. Meanwhile, the subgroups that performed TRPA on the ankle collectively made 16 errors (7.40%) out of 216 reproduced joint positions. These errors were divided into 6 for the SS subgroup, representing 5.55% of the reproduced positions and 10 for the FFRF subgroup, which corresponds to 9.26% of the reproduced positions.

Table 2: Number of correct responses in the SS and FFRF groups during TRPA.

Joint	Group	Angle (Movement)	Number of Correct Responses	Total Correct Responses N (%)
Knee	FFRF	45° (Flexion)	19	52 (86.67%)
		90° (Flexion)	16	
		110° (Flexion)	17	
	SS	45° (Flexion)	17	49 (81.67%)
		90° (Flexion)	15	
		110° (Flexion)	17	
Ankle	FFRF	10° (Dorsiflexion)	30	98 (90.74%)
		0° (Neutral)	33	
		20° (Plantar Flexion)	35	
	SS	10° (Dorsiflexion)	35	102 (94.45%)
		0° (Neutral)	32	
		20° (Plantar Flexion)	35	

When comparing the total correct responses of the SS group in knee and ankle joint positions with those obtained by the FFRF group in the same joints, it is observed that the difference is not significant. The SS group achieved a total of 151 correct responses (89.88%), while the FFRF group obtained 150 correct responses (89.29%) out of a possible 168.

Regarding the comparative analysis of errors, it is noted that the SS group made only 17 errors (10.12%) in 168 reproduced positions. On the other hand, the individuals in the FFRF group recorded a total of 18 errors (10.71%) in the same 168 reproductions of the predetermined joint amplitude degrees.

4. Discussion

The results demonstrate that individuals in the Final Phase of Physiotherapeutic Rehabilitation (FFRF) after prolonged immobilization of the knee and ankle due to traumatic injury do not exhibit proprioceptive deficits when compared to Healthy Subjects (HS). This conclusion is supported by the fact that the difference in the number of correct and incorrect responses between the groups is extremely small-only one position-with a minimal advantage for the SS group (just one more correct response).

According to Petrella et al.[11], proprioception decreases with aging. This finding was confirmed in a study that evaluated the proprioception of young individuals (19-27 years) and older adults (60-86 years), indicating that only individuals of advanced age were significantly affected. In our sample, composed of individuals aged 20-45 years, it was observed that the subgroup with the highest number of correct responses was predominantly composed of women (88.89%), with an average age of 26.11 years-the second-lowest average among the four subgroups. On the other hand, the group with the highest number of errors was

predominantly composed of men (60%), with an average age of 38.2 years-the highest among the four subgroups, as shown in Tables 1 and 2. Other anthropometric characteristics do not appear to influence proprioception. Nevertheless, the difference in the number of errors between the SS and FFRF groups is insufficient to assert that age, within the range of 20-45 years, is a clinically relevant factor.

Although Dhillon, Bali and Prabhakar et al.[12] indicate that, following reconstruction of the Anterior Cruciate Ligament (ACL), there may be a reduction in proprioception due to the partial removal of articular and cutaneous receptors, no studies suggest proprioceptive deficits in the FFRF phase. Furthermore, the same authors emphasize that functional recovery is improved when remnants of the injured ACL are preserved during surgery, as this could promote regeneration or growth of proprioceptive fibers in the reconstructed ligament.

According to Cooper, Taylor and Feller et al.[13], the rupture of local mechanoreceptors due to an ACL injury activates compensatory mechanisms from other proprioceptive sources, contributing to knee stabilization. This compensation can be enhanced through "destabilizing activities," referring to exercises included in proprioceptive training.

Additionally, in the absence of Central or Peripheral Nervous System injuries, it is possible that, even with local impairments due to traumatic injury, the mechanoreceptors in the post-immobilized joint are regenerated. Alternatively, other receptors may compensate for the dysfunction, ensuring adequate proprioceptive performance.

Studies like that of Furlanetto et al.[14], which evaluated proprioception, body balance and knee functionality in patients six months after ACL reconstruction, support our findings. When comparing these patients with individuals with no history of lower limb pathologies, the authors found no deficits in proprioception or postural control. The detected functional differences were also minimally significant, suggesting mechanoreceptor regeneration within this time frame.

According to Gokeler et al.[15], patients undergoing ACL reconstruction do not present clinically relevant proprioceptive deficits compared to healthy subjects. However, the study highlights the need for the development of more precise methods to evaluate proprioceptive function and the sensory-motor system. Similar results were obtained by Nagai et al.[16], who, when comparing joint position sense under different conditions, found no significant differences between reconstructed members and control groups.

Moreover, the study by Groot et al.[17], which investigated proprioceptive performance in athletes with patellar tendinopathy, found no significant differences compared to healthy athletes or between the affected and contralateral limbs. Similarly, Akbari et al.[18], when comparing healthy men and men post-ACL surgery subjected to balance and proprioceptive training, identified no significant differences between the evaluated groups. Additional studies, such as those, reinforce the absence of significant deficits despite the prescription of proprioceptive training in the treatment of traumatic injuries[10,19].

Finally, the so-called Proprioceptive Training, commonly used in the final phase of Physiotherapeutic Treatment, includes exercises aimed at improving joint stability through specific devices such as trampolines, inflatable discs and Swiss balls. Tavares, et al.[20] emphasize that joint stability depends not only on proprioception but also on factors such as vision, tactile sensitivity, muscle strength and balance. Thus, considering the absence of significant proprioceptive deficits in the FFRF phase and the multifactorial nature of the systems involved, it may be appropriate to propose a more suitable name for this training[21].

5. Conclusion

Based on the data obtained in this study, it was concluded that individuals in the Final Phase of Physiotherapeutic Rehabilitation (FFRF) exhibited proprioceptive performance similar to that of Healthy Subjects (HS). This supports the hypothesis that there is no proprioceptive deficit during this phase of physiotherapeutic treatment, even after prolonged immobilization of the knee or ankle due to traumatic injury.

Given these findings, it can be stated that the goal of the exercises used in the Final Phase of Rehabilitation, commonly referred to as Proprioceptive Training, is to restore joint stability through the improvement of sensorimotor integration. This integration involves functions such as balance, muscle strength, reaction time and motor coordination, indicating that its focus extends beyond proprioception alone. Thus, we propose a new nomenclature for "Proprioceptive Training," as the exercises employing devices such as balance boards, trampolines, wobble discs and others aim to enhance joint stability, which is essential for functional recovery.

Finally, considering the absence of proprioceptive deficits and the involvement of multiple systems in achieving joint stability, it is appropriate to suggest a reevaluation of the term "Proprioceptive Training" to better reflect its comprehensive role in functional rehabilitation. We propose the term "Dynamic Joint Stabilization Training" as a more accurate designation for these exercises.

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