

# Comparative study of virtual rehabilitation and kinesiotherapy for knee torque among the elderly

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## ABSTRACT

Aging causes a variety of neurological and psychomotor changes, such as decreases in muscle strength, proprioception, balance, and cognition, among other things. Therapeutic exercises help in reducing these deficits and contribute to functional improvement and quality of life.

**Objective:** This study aimed to compare the effects of virtual rehabilitation and exercise therapy on knee torque among the healthy elderly. **Method:** The subjects were divided randomly into two groups: seven participants performed exercises with virtual rehabilitation composing the Virtual Rehabilitation group (RV) ( $69.7 \pm 5.5$  years,  $71.8 \pm 13.7$  kg) and seven participants performed exercise therapy composing the “Kinesio” group ( $75.4 \pm 5.7$  years,  $64.7 \pm 17.2$  kg). The torque of the knee extensor and flexor muscles was assessed with the Biodex System 3 isokinetic dynamometer. The protocol consisted of three isometric contractions of 5 seconds at knee flexion angles of  $45^\circ$  and  $60^\circ$  (see page 5) and five repetitions of concentric isokinetic contractions at  $60^\circ$ ,  $180^\circ$  and  $300^\circ/s$  velocities. The treatment protocol was conducted for 3 months, with 50 minutes per session, twice a week. In the VR group, two modes of games were used, involving tasks of challenges and interactive feedback of body awareness. The Kinesio group performed the same virtual rehabilitation exercise protocol, but without video game stimulus. The ANOVA test was used for statistical analysis, followed by the *post hoc Tukey HSD* with a significance level of  $p < 0.05$ . **Results:** The peak isokinetic concentric and isometric torques of knee extension and flexion were higher after intervention for both groups. **Conclusion:** Therefore, it can be concluded that conventional rehabilitation through exercise, as well as the innovative technique of virtual rehabilitation, are effective to increase extensor and flexor knee torque, which can help to reduce the incidence of falls among the elderly.

**Keywords:** Aging, Exercise, Muscle Strength, Rehabilitation

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## INTRODUCTION

The World Health Organization (WHO) defines the elderly population as people aged 60 or older in developing countries and aged 65 years or older in developed countries.<sup>1</sup> By 2025, a growth of 223% is expected on the planet, which means around 694 million elderly people and, according to the literature, by that time there will be approximately 1.2 billion people aged older than 60 years. By 2050, two billion people will be elderly and from those, 80% will be in developing countries.<sup>2</sup>

Although the worldwide increase of the elderly population in recent decades indicates a significant increase in the quality of life, it is a fact that aging generates morphological, functional, and biochemical alterations that leave the organism predisposed to intrinsic and extrinsic changes that result in the decline in functional capacity and independence of that population.<sup>3</sup>

Aging is understood as a natural process in the life of human beings, marked by the progressive decrease of functional reserve (senescence). However, when accompanied by pathological conditions and emotional stress that require assistance, it is called senility.<sup>4</sup> Functional incapacity, caused by the functional reserve's progressive decline and that is aggravated when associated with pathological conditions exerts a negative impact in the individual's well-being, leading to greater need for care.<sup>5</sup>

Alterations in balance control and protection reflexes are some of the factors that come with aging and hinder the corporeal mobility of the elderly,<sup>6</sup> in addition to the decline of muscle strength and atrophy that occur, partly because of a reduction in the number and size of type IIb muscle fibers-sarcopenia<sup>7</sup> and that damage the maintenance of functional skills and, consequently, of quality of life.

The loss of muscle strength during a person's life is gradual and can be considered that in the second and third decade of life, the individual has its greatest peak of strength. Between the ages of approximately 30 and 50 years, the strength remains relatively stable or it can decline slowly. Around the age of 60, there is an accentuated decline and, from 70 on, the loss is more accelerated.<sup>8</sup>

One way to combat or retard these declines is the practice of physical activity, employed in the prevention and control of

chronic-degenerative diseases,<sup>3</sup> which generate benefits for maintaining one's function, minimizing the deleterious effects of aging.<sup>9</sup>

A kinesiotherapeutic program based on exercises to improve balance, flexibility, and muscle strength can maintain or recover certain sensory-motor and cardiovascular functions.<sup>6,10,11</sup> Exercising can improve endurance and the static and dynamic balance of the elderly, which can help reduce the risk of falling and increase functionality in their activities either of daily life or instrumental.<sup>10,12</sup> Furthermore, kinesiotherapy provides improvement in the social, mental health, and physical aspects, allowing greater autonomy and quality of life for the elderly.<sup>3,13</sup>

Virtual rehabilitation exercises have become an option in physiotherapeutic rehabilitation programs.<sup>14</sup> In recent years, there has been an increase in the use of virtual environment games as a therapeutic tool to treat the physical and cognitive functions of the elderly.<sup>15</sup> Today, it is commonly used successfully by people who have stroke sequelae with motor loss and/or deficiencies in body balance.<sup>6</sup>

The positive results of using a virtual environment in rehabilitation include posture and balance corrections and increases in the locomotion capacity, the range of movement of the upper and lower limbs, motivation,<sup>16</sup> improvement of motor coordination, endurance, and muscle strength, in addition to the cognitive work, since attention, concentration, and reasoning are needed to execute the activity.<sup>17</sup>

Due to the rapid growth of the elderly population, physiotherapy needs more and more to develop new models of assistance to the elderly, always prioritizing care that enables their better functional performance and that allows a more complete work, involving and demanding more from the different sensory motor and cognitive capabilities, in addition to the social aspect. Although there are not many therapeutic resources dedicated to the treatment, it is necessary to innovate and associate efforts to develop new technological possibilities of learning motor tasks. It is known that a motor skill is simultaneously cognitive; therefore, it is important for the quality of life of the individual, during his motor recovery, that he also develops a mental image of the behavior to be learned. Based on that principle, virtual rehabilitation interactivity can provide improvement in muscle strength and consequently increase functional performance. The present study seeks to contribute to the knowledge of

a new therapeutic technique and its effect on the assistance to the elderly population.

## OBJECTIVE

The objective of this study was to evaluate and compare the effects of virtual rehabilitation and kinesiotherapy on the torque of the knee extensor and flexor muscles of the healthy elderly.

## METHOD

This study was a randomized clinical trial, with the intervention of two groups of elderly recruited through a gerontology waiting list at the São Judas Tadeu University Physiotherapy Clinic (USJT).

Fourteen participants were selected and randomly divided into two groups: seven participants did virtual rehabilitation exercises forming the Virtual Rehabilitation group (VR) (69.7 ± 5.5 years; 71.8 ± 13.7 kg), and seven participants did kinesiotherapy, forming the Kinesio group (75.4 ± 5.7 years; 64.7 ± 17.2 kg).

In this study, individuals were included of both genders, aged 65 or older, who were not receiving any other associated therapies, not presenting any disabling pathologies, and who scored 23 or higher in the mini-mental state examination (MMSE) for those who completed fifth grade in school or who scored 19 for those who completed only up to the fourth grade.

Four participants were excluded from the study because they were not available to follow the treatment protocol during the period of time proposed or for not having an appropriate attendance.

All the participants went through a physiotherapeutic evaluation that included personal data and general state, followed by the Mini-mental State Examination.

The subjects were evaluated for isometric and concentric isokinetic torque of the knee extensor and flexor muscles with the help of a *Biodex® System 3-PRO* isokinetic dynamometer. They were positioned in a chair regulated according to their height, keeping hips and knees at a 90° flexion; two Velcro straps were used to stabilize the lower limbs, one at the middle third of the thigh and the other three centimeters above the lateral malleolus. The lateral epicondyle of the femur was aligned with the mechanical axis of the dynamometer.

In the isometric evaluation protocol, the participants did three contractions for five seconds each, with the same time for rest, at two different angular positions: 45° and 60° flexions. Resting time between the positions was 30 seconds. The isokinetic protocol was composed of concentric contractions of the knee extensor and flexor muscles at three angular velocities: 60°/s, 180°/s, and 300°/s. Five repetitions at each velocity were made and the resting time between the velocities was 30 seconds. The participants were encouraged verbally (voice commands) during the tests to exert the maximum force possible during the knee flexion and extension movements and the dominant lower limb was the one evaluated.

The subjects had two exercise sessions per week for three months, totaling 24 sessions of 50 minutes each. This period was used for the two interventions: virtual rehabilitation and kinesiotherapy.

The virtual rehabilitation protocol consisted of two modalities of games in doubles, with the supervision and orientation of the researchers. In the first modality, the participant had the goal of reaching specific targets such as destroying floating blocks as fast as possible, hitting the center of the blocks, stepping as fast as possible on the lights that would light up on the floor, accompanying the rhythm proposed by the game, in addition to moving in circumduction with the hip as fast as possible until hitting all the floating balls without letting the hula hoop fall. In the second game modality, the participant had to perform the activity according to the commands of a virtual personal trainer that offered feedback on how to execute the movements correctly to achieve the ideal results for each exercise. In this stage, dynamic exercises (leg curl, step, and dodge) were made for aerobic conditioning, coordination, rhythm, and memory.

In the kinesiotherapy protocol, the same exercises were performed from the virtual rehabilitation protocol, but the researchers gave the verbal commands instead of the video game. The exercises were simulation of punches with crossing movements, stepping on colored strips glued to the floor in a semi-circle, following the order of colors proposed by the researcher, and making circumduction movements with the hips. After that, dynamic exercises were made to train aerobic conditioning, coordination, rhythm, and memory, as it was done with the VR group.

The present study was approved by the São Judas Tadeu University Ethics

and Research Committee (CEP/USJT Nº 6887/2012). All the participants were informed of all the procedures to be made and, after agreeing to participate in the study, they signed a Free and Informed Consent Form. The ethical principles contained in the Declaration of Helsinki (2000) were fulfilled in consonance with resolution 196/96.

A two-way variance analysis (ANOVA) and the Tukey post hoc test were made to analyze the differences. The significance index adopted was 0.05. The factors analyzed were: intervention (Kinesion and VR) and phases (pre and post intervention); and the dependent variables were the knee extensor and flexor torque.

## RESULTS

The result for the evaluation of the knee extensor concentric isokinetic peak torque showed a statistically significant difference for the phase factor ( $F_{(1,414)} = 117.21$ ;  $p < 0.0000$ ). The Tukey post hoc test indicated that the peak concentric isokinetic extensor torque was greater in the post intervention phase (Figure 1).

Upon analyzing the knee extensor isometric peak torque, the ANOVA showed the effect of the phase factor ( $F_{(1,163)} = 63.10$ ;  $p < 0.0001$ ). The Tukey post hoc test indicated that the peak isometric extensor torque was greater in the post intervention phase, regardless of the group (Figure 2).

For the concentric isokinetic knee flexor peak torque there was only the effect of the phase factor ( $F_{(1,415)} = 62.14$ ;  $p < 0.0001$ ). The Tukey post hoc test indicated that the peak torque was greater in the post intervention phase in both groups (Figure 3).

For the peak torque of the isometric knee flexor there was only the effect for the phase factor ( $F_{(1,166)} = 25.82$ ;  $p < 0.0001$ ). The Tukey post hoc test confirmed that the peak torque of the isometric knee flexor was greater in the post intervention phase, regardless of the group analyzed (Figure 4).

## DISCUSSION

Virtual reality is being incorporated into physiotherapeutic treatment as a resource that demands sensory motor interaction in various aspects. The social and emotional areas are also worked when a virtual environment is used, since it enables innovation and

interaction with other individuals. Its motivational, competitive, and dynamic nature has been pointed out as positive in its use for the assiduity of the patients and their consequent functional improvement.<sup>17,18</sup>

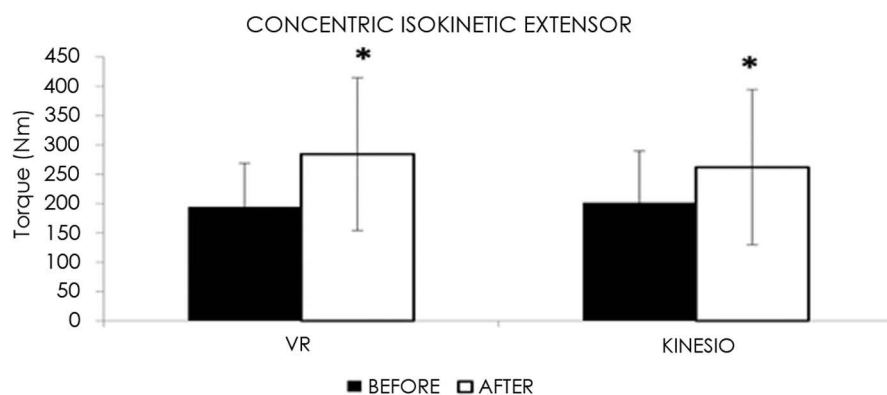
Using this new resource as a treatment raises a few questions as to its efficacy. Along these lines, the present study aimed to evaluate and compare the effects of virtual rehabilitation and kinesiotherapy in the elderly regarding knee extensor and flexor torque.

It is known that a decline in muscle strength and proprioception, among other changes characteristic of senescence, can generate an impairment in the functional performance and quality of life of the elderly, aggravating the risk of falling in this population.<sup>8</sup>

The knee extensor and flexor muscles of the dominant lower limb were submitted to an isometric and concentric dynamometric isokinetic evaluation. This standardization was adopted based on the literature,<sup>8,19,20</sup> which showed the peak torque between lower limbs and found no significant difference between the dominant and non-dominant limbs. Therefore, for the present study, only the dominant lower limb was evaluated.

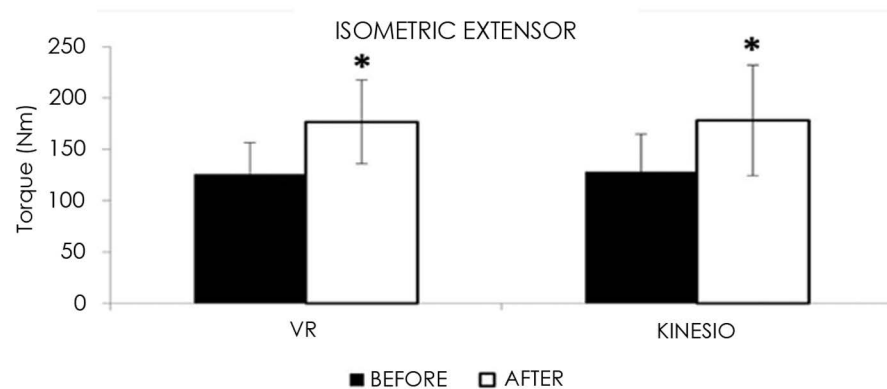
In the knee extensor and flexor concentric isokinetic torque analysis, an increase in peak torque for both groups after the intervention was obtained, regardless of the angular velocities adopted. This finding is consonant with the study by Wibeling et al.<sup>20</sup> that compared the effects of conventional physiotherapy with those of virtual reality in relation to the muscle strength of 71 elderly females with knee osteoarthritis. The elderly females were divided into two groups, using angular velocities similar to those used in the present study and they observed an increase in the peak torque for both groups.

In the isometric torque evaluation of knee flexion and extension, the peak torque was greater in both groups after the intervention. Aveiro et al.<sup>21</sup> obtained the same results evaluating the effects of a physical activity program on the balance and strength of the quadriceps femoris in 16 older females with osteoporosis. The protocol was followed for 12 weeks, with three weekly sessions of one hour each and consisted of open kinetic chain exercises to strengthen the lower limbs. After the intervention, the elderly females showed a significant increase in the isometric torque of their quadriceps.



\*  $p \leq 0.05$  between phases

**Figure 1.** Mean and standard deviation of the peak concentric isokinetic knee extensor muscle torque obtained in the pre and post intervention phases for the Virtual Rehabilitation and Kinesio Groups.



\*  $p \leq 0.05$  between phases

**Figure 2.** Mean and standard deviation of the peak knee isometric extensor muscle torque obtained in the pre and post intervention phases for the Virtual Rehabilitation and Kinesio Groups.

Lopes et al.<sup>22</sup> observed increases in the peak torque of the knee extensor and flexor muscles of 68 elderly females who practiced exercises, corroborating our findings. The subjects were randomly divided into two groups and in the lower age group the peak torque was even greater.

A study by Carvalho et al.<sup>23</sup> with 32 elderly of both genders aimed to determine the effect of a generalized physical activity program that lasted six months. Each session consisted of a warm-up through walking, flexibility exercises, localized muscle work with emphasis on strengthening lower limbs using rubber bands, aerobic

work, coordination exercises, playful balance games, finishing up with stretching. The authors concluded that this approach did not generate isokinetic muscle strength in the lower limbs, but pointed out that the objective of the study was to improve the physical abilities to perform daily life activities such as motor coordination and balance, synergism between the muscles to climb and descend stairs, to walk, to get up from the bed, among other things. The results of that study diverged from those found in the present study, for we found that even conventional physiotherapy done with kinesiotherapy was able to increase the peak

torque of the lower limb muscles. This difference probably occurred due to all the exercises of the present study involving activities with the lower limbs.

The functional activities of day to day are determined by the capacity and degree of muscle strength.<sup>18</sup> Lack of physical activity can accelerate alterations in the organism of an elderly person, among them the reduction in the number and size of muscle fibers, especially type II, responsible for strength and velocity at the moment of muscle contraction.<sup>24</sup> After the age of 60, there is a decline of about 15% and, after age 70, this decline is around 30% in the individual maximal peak torque with every decade.<sup>8</sup>

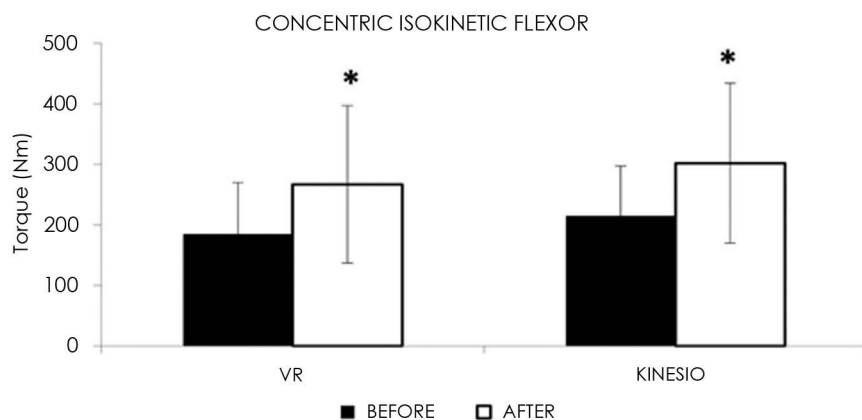
The regular practice of physical activity is a preventive measure against the muscle changes that occur with aging.<sup>25</sup> The exercises proposed in this study were prepared according to those used in clinical practice for the elderly population, with emphasis on the lower limbs, as it is known that the decline of lower limb strength is more accentuated than what is observed in the upper limbs.<sup>8</sup>

Virtual reality has demonstrated promising results in the rehabilitation of the elderly by promoting improvements in agility, posture, balance, and coordination,<sup>26</sup> which can also be projected to other population groups. Merianset et al.<sup>27</sup>, You et al.<sup>28</sup> and Monteiro Junior et al.<sup>29</sup> reported improvements in posture, balance, capacity of locomotion, and range of motion in the upper and lower limbs of patients who had suffered a stroke. Deutsch et al.<sup>30</sup> used virtual rehabilitation with an adolescent with cerebral palsy and found improvement in postural control and visual perception, and an increase in functional mobility.

In the present study, the peak torque increase occurred for both groups after the application of intervention protocols, not showing any efficacy of one intervention over the other, which corroborates the literature mentioned above, in which different exercise protocols were applied with the same effect on the torque.

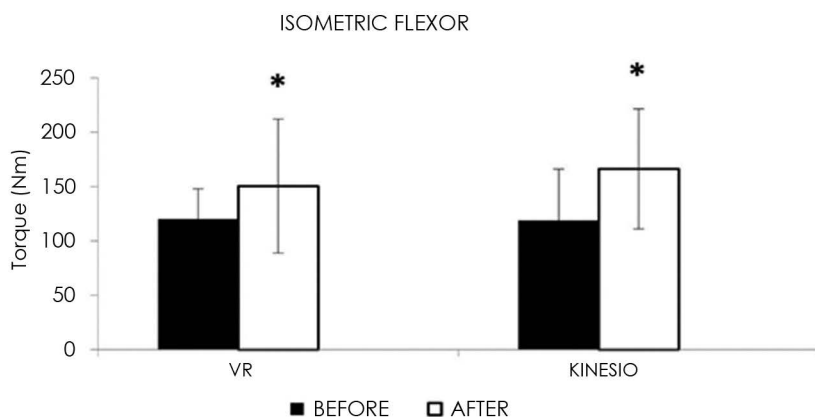
## CONCLUSION

Kinesiotherapy, as well as virtual rehabilitation, was effective in gaining knee extensor and flexor torque, which allows more possibility of resources during the rehabilitation of elderly individuals.



\*  $p \leq 0.05$  between phases

**Figure 3.** Mean and standard deviation of the peak concentric torque of the isokinetic knee flexor muscles obtained in the pre and post intervention phases for the Virtual Rehabilitation and Kinesio Groups.



\*  $p \leq 0.05$  between phases

**Figure 4.** Mean and standard deviation of the peak torque of the isometric knee flexor muscles obtained in the pre and post intervention phases for the Virtual Rehabilitation and Kinesio Groups.

Torque increase associated with the benefits of physical activity brings improvement of balance, flexibility, and proprioception to the individual and increases self-esteem, providing greater functional mobility, independence, and lower risk of falling for the elderly.

Despite virtual reality becoming a more and more accepted therapeutic intervention in the treatment of patients with various pathologies and of specific populations such as

the elderly, there are still few published studies in this area, which is why it is necessary to develop new studies to increase the quality of the scientific information and clinical practice.

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