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RESEARCH

Immediate Effect of Passive Joint Mobilizations on Hand Reaction: A Randomized, Single-Blind Study

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Abstract

Reaction time is a measure of neuromuscular performance and motor function. The capacity for rapid response is linked to enhanced performance in a range of areas, including gaming, academic pursuits, the visual and performing arts, martial arts, and personal protection. The purpose of this single-center, parallel, randomized-controlled study was to investigate the immediate effect of passive joint mobilization (PJM) on hand reaction time (HRT) in healthy subjects. The study population consisted of 351 subjects, including hospital staff and university students. Seventy-six people who met the eligibility criteria were included and 66 of them completed the study. Participants were randomly allocated to either passive mobilization (PM) group or sham mobilization (SM) group. In the PM group, participants received a glide at the wrist, first metacarpophalangeal joint (1st MCP), and carpometacarpal joint (CMC). Participants in the SM group maintained a fixed position in which their joints were tactilely stimulated by pinching and releasing rather than gliding. The ruler drop test was used to assess hand response before and immediately after the applications. HRT was significantly decreased in both groups compared to the pre-intervention period ($p < 0.05$). Although small effect sizes were observed in both groups, the effect size in the PM group (*d*, 0.285) was greater than in the SM group (*d*, 0.179). Passive joint mobilization represents an efficacious technique when immediate reduction of reaction time is required in healthy subjects. (NCT06168747).

Keywords Passive joint mobilization · Hand reaction time · Immediate effect · Motor function

Introduction

The amount of time it takes for an individual to generate an appropriate voluntary response to a stimulus is referred to as the reaction time (RT) [1]. RT types consist of simple reaction time (SRT), recognition reaction time (RRT), and cognitive reaction time (CRT). SRT is a simple response to a single stimulus, while RRT requires a cognitive process of selecting the optimal response to multiple stimuli, depending on the type and form of the stimuli. CRT entails identifying the meaning of stimuli, making associations, and applying knowledge to develop an optimal cognitive response that aligns with the complexity of the stimulus [2]. SRT is utilized as a measure of Motor Cognitive Processing Speed (MCPS) to assess executive and neuropsychological function. Faster MCPS is associated with enhanced performance in various domains, including gaming, studying, fine arts, martial arts, and defense [3]. Several factors, including age, gender, hand dominance (left or right), central and peripheral vision, practice, fatigue, fasting, breathing cycle, personality type, exercise, and subject intelligence can affect average human reaction time [4]. Reaction time, which reflects a person's alertness, is crucial in occupations such as driving, military service, piloting, sports, medicine, nursing, and security, where heightened awareness is essential [5]. In addition, improving reaction times can enhance an athlete's performance by optimizing decision-making and increasing attention span [6].

Manual techniques, such as massage, joint mobilization, and manipulation, are particularly effective for addressing

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mechanical alterations in the affected joint [7]. Healthcare providers commonly employ manual interventions, such as passive joint mobilization (PJM), to enhance function [8]. Notably, mobilization prior to exercise has the potential to affect afferent input, leading to plastic changes in the neural system, which can contribute to motor learning and ultimately improve function and performance [9, 10].

Several studies in the literature have explored the immediate effect of manual therapies on reaction time. In a study conducted by Kelly et al. [11], it was found that individuals who received spinal manipulation demonstrated a significant enhancement in their performance on a complex reaction time task. Furthermore, two studies have indicated that hand and head movements in response to visual stimuli were executed more rapidly following spinal manipulation [12, 13]. Conversely, a study by Kacmaz et al. [14] reported no immediate difference was identified between the Mobilization With Movement and sham application regarding elbow proprioception in healthy subjects. Upon analyzing the data, it becomes evident that the influence of manual therapy on proprioception has been primarily investigated. However, we recognize that both reaction time and joint position sense are critical components of neuromuscular performance and motor function [15].

The aim of this study is to investigate how PJMs affect hand reaction time (HRT) in healthy individuals. The first hypothesis posits that following PJM, the dominant hand's reaction speed will improve. The second hypothesis suggests that sham treatment will have no effect on the reaction time of either hand.

Material and Methods

Study Design

This study was a parallel, randomized, placebo-controlled trial with a single-blind approach involving healthy participants at Kirsehir Ahi Evran University Physical Therapy and Rehabilitation Hospital. The study was conducted in accordance with the Declaration of Helsinki after receiving approval from the Haliç University Ethics Committee (26.12.2023/299). Written informed consent was obtained from all patients. The study was registered on ClinicalTrials.gov with the identifier NCT06168747.

Participants

Individuals initially evaluated for inclusion and exclusion criteria. Those eligible for the study were randomly allocated to either the passive mobilization (PM) group or the sham mobilization (SM) group using a computer-generated sequence (https://www.randomizer.org/). Participants are unaware of the treatment assigned to them, but those administering the treatment and evaluating outcomes know the assignments. This was achieved by using coded labels for treatment groups that did not reveal the true nature of the treatment.

A total of 76 healthy individuals, ages between 18 and 65, were included in the study from December 2023 to February 2024. Participants who met any of the following criteria were excluded from the study: (1) those who reported elbow, hand, shoulder, or neck discomfort in the last 6 months, (2) those with pain in the upper extremity, (3) those with a neurological problem affecting sensations (as it may affect HRT), and (4) those who refused to participate in the study.

Intervention

In the PM session, the participants received a mediolateral glide in the wrist, anteroposterior glide in the first metacarpophalangeal joint (MCP), and anteroposterior-mediolateral glide in the carpometacarpal joint (CMC) at a frequency of 2–3 Hz per second, totaling 120–160 Hz per minute. The procedure lasted 4 min and was completed in a single session. The glides were performed by a physiotherapist (O.F.O.) with 10 years of experience (Fig. 1). Participants were seated comfortably with their hands resting on a table. While stabilizing the proximal segment with the left hand, the physiotherapist applied a sliding motion to the distal segment with the right hand. The joint capsule and passive tissues that support and stabilize the joint were stretched using grades III and IV [16]. The rate of mobilization was maintained at 2 Hz (120 movements per minute for 1 min) [17].

In the sham mobilization session, participants maintained a fixed position, receiving tactile stimulation through squeezing and releasing, rather than gliding. A previous study that included a sham intervention of the MWM technique maintained the active movement component without gliding [18]. To preserve participant blinding in our study, the sham intervention involved squeezing and releasing at the same frequency as in the active study group [19].

HRT was evaluated using the Ruler Drop Test [20], which has demonstrated acceptable reliability and criterion validity [21]. HRT was measured while participants were seated in a chair with their forearms resting comfortably on a table. The thumb and index fingertips were positioned parallel to each other, 10 cm above the table. A physiotherapist held a 50-cm ruler between the participants' thumb and index fingers and instructed them to catch the ruler with their fingers when it was released, while looking directly at the midpoint of the ruler. The measurement was recorded at the top of the thumb when the participant caught the ruler. This process was repeated five times and the results were averaged [22]. The reaction time was calculated using the formula below.

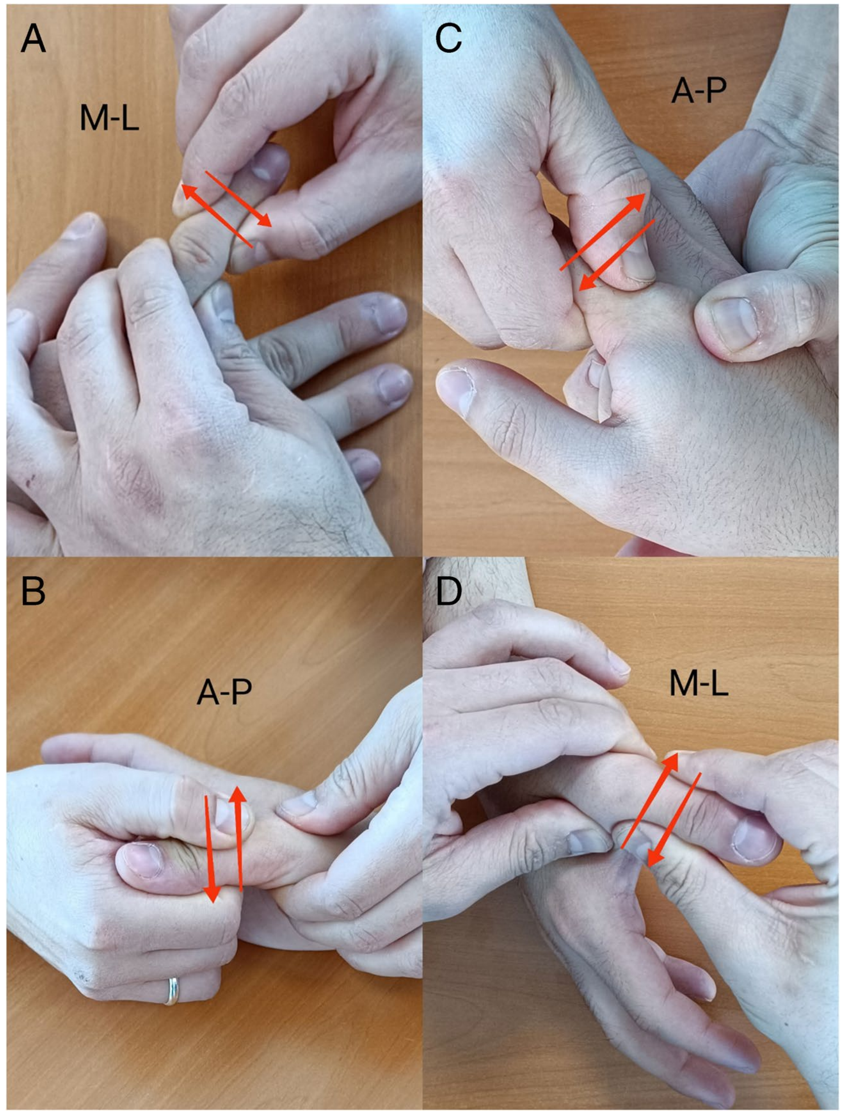

Fig. 1 Passive joint mobilization applications. **A** 2 DIP mediolateral glide; **B** CMC anterio-posterior glide; **C** 2 MCP anterio-posterior glide; **D** CMC mediolateral glide; A-P, anterior–posterior; M-L, medial–lateral

Evaluation was performed before and immediately after the applications [21].

- Reaction time = $\sqrt{2} \times$ the distance the ruler fell (mm) / speed of gravity (980 s)

Statistical Analysis

The sample size was calculated based on the reaction time score from the study by Bokil et al. using G-Power 3.1.9.2 software [23]. Minimum of 42 participants were required to obtain a sample with an effect size of $d = 0.79$, 80% test power, and a first-type error probability of $a = 0.05$. Data from 66 participants who completed the study within the specified time interval were analyzed.

Statistical analyses were conducted using Statistical Package for Social Sciences (IBM® SPSS® Statistics 26.0-USA) program. Categorical variables are expressed as percentage (%) values, while descriptive statistics for numerical variables were given as arithmetic mean ± standard deviation (M ± SD). The Shapiro–Wilk test was employed to assess the normality of the variables. As the variables did not show normal distribution, non-parametric tests were utilized. The Mann–Whitney *U* test was applied for inter-group comparison, and the Wilcoxon Signed-Rank test was used for intra-group comparisons. The accepted level of statistical significance was $p < 0.05$ [24].

Results

Demographic data of the participants are presented in Table 1. The primary outcome of the study was HRT, measured in seconds with the Nelson Hand Reaction Test. The second outcome aimed to determine how the reaction time changes instantaneously after passive joint and sham

Table 1 Demographic of the participants

Characteristics	Mobilization group (M ± SD) (*n* = 33)	Sham group (M ± SD) (*n* = 33)	*p**
Age (years)	22.70 ± 1.33	22.42 ± 1.64	0.257
Weight (kg)	65.94 ± 15.84	66.33 ± 18.46	0.888
Height (m)	1.68 ± 0.09	1.67 ± 0.10	0.512
BMI (kg/m^2)	23.02 ± 3.32	23.50 ± 5.27	0.868
Dominant side (right/left)	32/1	30/3	0.306

BMI body mass index, *Mann–Whitney *U* test; $p < 0.05$

mobilization. Application of passive joint mobilization on the dominant side resulted in a statistically significant decrease in HRT ($p < 0.05$), confirming the study's initial hypothesis. Both passive joint mobilization and sham mobilization resulted in reductions in reaction time for both hands. However, the decrease in reaction time was statistically significant between the groups on the dominant side ($p = 0.01$), while no significant difference was observed between the groups on the non-dominant side ($p = 0.928$). Consequently, the second hypothesis of the study was not supported. Calculation of the effect size (80% CI) indicated that the effect of mobilization on the dominant side was greater than that on the non-dominant side; however, the effect sizes were small (Table 2). In accordance with the nature of passive mobilization, no side effects were observed in the participants, as the applications were performed within physiological limits.

Discussion

This study indicated that both passive joint mobilizations and sham mobilizations improved HRT immediately. Although the magnitude of the effect was small in both applications, the impact of PJM on reaction time was greater on the dominant side. Mobilization can be utilized prior to activities that have a high proprioceptive demand, as it can enhance proprioception [25]. Additionally, mobilization before exercise has the potential to affect afferent input, leading to plastic changes in the neural system. This may contribute to motor learning and ultimately improve function and performance [26].

As participants' age increased, their reaction times correspondingly increase [27]. Furthermore, studies focusing on hand dominance have consistently shown that the reaction time of the non-dominant hand is significantly slower than that of the dominant hand [28]. Based on this, we believe that developing training strategies aimed at improving reaction time on the non-dominant side—particularly in sports involving both upper extremities—can be beneficial for sports performance as well as for occupational activities.

In the study by Ceylan et al., which examined the efficacy of MWMs compared to conservative physiotherapy in reducing perceived symptoms in mild and moderate carpal tunnel syndrome (CTS), hand reaction was measured using the Ruler Drop Test. According to the data obtained, the treatment applied to both groups did not show a positive effect on reaction time [29]. This indicates that the effect of PJM and MWM in the context of CTS rehabilitation on reaction time is very limited. However, despite these limited results, the literature suggests that changes in reaction time may serve as predictors of musculoskeletal pathologies [30]. In this respect, it is important for clinicians to evaluate the reaction time in order to recognize potential pathologies.

Chouamo et al. [28] demonstrated that the reaction time of the dominant hand is faster than that of the non-dominant hand. The mean reaction time of the dominant hand was 0.237 s, while that of the non-dominant hand was 0.270 s. Similarly, in our study, the mean reaction time was 0.188 s for the dominant hand and 0.191 s for the non-dominant hand. These findings suggest that the faster reaction time of the dominant hand may be related to its increased usage. An additional explanation for the discrepancy in findings could be the difference in the age range of the participants in the two studies. In the study conducted by Chouamo et al., the participants ranged in age from 20 to 39 years, whereas in our study, they ranged from 20 to 25 years. Also, Rabbit et al. demonstrated that the preferred hand has a quicker reaction time compared to the non-preferred hand [31]. This suggests increased response readiness due to hand preference. The neurons transmitting messages between the hand and brain operate faster for the dominant hand due to increased usage. Consistent repetition of messages along

Table 2 Comparison of reaction time and effect size

Reaction time	Groups	Pre-treatment (M ± SD)	Post-treatment (M ± SD)	Δ	*p**	*d*	*p***
Dominant hand	Sham	0.193 ± 0.019	0.187 ± 0.016	**− 0.006**	**0.013**	0.285	**0.010**
	Mobilization	0.202 ± 0.021	0.192 ± 0.019	**− 0.01**	**0.002**		
Non-dominant hand	Sham	0.194 ± 0.018	0.189 ± 0.039	**− 0.005**	**0.035**	0.179	0.928
	Mobilization	0.199 ± 0.020	0.195 ± 0.027	**− 0.004**	**0.023**		

M mean, *SD* standard deviation, *Wilcoxon Signed-Rank test; **Mann–Whitney *U* test; $p < 0.05$

the same pathway can enhance motor skills, supporting the adage "practice makes perfect." This concept applies not only to comparing reaction times between hands, but also to comparing their variability [32].

Given that occupational differences and grip strengths were not considered in the present study, future research should investigate the relationship between muscle strength, occupational choice, position sense, and reaction time. Additionally, future studies should focus on how reaction times vary across different age groups, how occupational differences affect reaction time, and the short-, medium-, and long-term effects of mobilization practices in this population.

Strengths This study is randomized, blinded for the participants, used a sham application, and is among the first to examine the effect of PJM on HRT in healthy adults. Thus, our study contributes innovation to the literature by demonstrating that HRT in the dominant hand can be reduced instantaneously using PJM.

Limitations This study has several limitations that should be considered. The absence of a no-treatment control group, while ethically justified, limits the ability to determine whether PJM's effects are superior to no intervention. Additionally, the study evaluated only simple reaction time (SRT) related to visual stimuli, excluding other sensory modalities and complex cognitive processes. The focus on immediate effects, without assessing long-term impacts, further restricts the understanding of whether benefits persist or influence daily function and performance. The narrow age range of participants (18–65 years) limits generalizability, especially to children or elderly populations, and participant characteristics such as occupational background, muscle strength, and upper limb use frequency were not accounted for, potentially introducing variability. Furthermore, the study did not explore PJM's applications in clinical populations, such as those with musculoskeletal disorders or undergoing rehabilitation, which limits its relevance to these groups. The observed effect size, while statistically significant, was small, raising questions about clinical relevance and the need for optimization of PJM parameters. Lastly, the exclusive focus on reaction time as an outcome measure overlooks other kinematic parameters like hand strength and coordination, which could provide a more comprehensive understanding of PJM's effects. These limitations underscore the need for future research to expand on these findings, including long-term, diverse population studies and broader outcome measures, to better understand PJM's efficacy and applications.

Clinical Relevance

- Passive joint mobilizations immediately reduce dominant HRT in healthy individuals.
- Although sham mobilization also reduces reaction time in the hand, the effect is not as significant as with active mobilization.
- Despite the age difference, participants' total HRTs were below average compared to normative values.

Conclusion

The findings of this study showed that PJM application caused a decrease in hand reaction time in healthy subjects and this decrease was observed especially in the dominant hand. It was also found that the rate of decrease in hand reaction time varied depending on age and previous use.

Abbreviations PJM: Passive joint mobilization; HRT: Hand reaction time; PM: Passive mobilization group; SM: Sham mobilization group; 1st MCP: First metacarpophalangeal joint; CMC: Carpometacarpal joint; RT: Reaction time; RRT: Recognition reaction time; MCPS: Motor Cognitive Processing Speed; HRT: Hand reaction time; MWMs: Mobilization with movements; CTS: Carpal tunnel syndrome

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Author Contributions OFO- Design of the study, Data collection, Writing-Original Draft; AT-Data collection, Data analysis; SS-Data analysis, Data interpretation, Critical reading, Writing; NT-Data interpretation, Critical reading.

Data Availability Data is provided within the manuscript or supplementary information files.

Code Availability Not applicable.

Declarations

Ethics Approval The study was conducted in accordance with the Declaration of Helsinki after receiving approval from the Haliç University Ethics Committee (26.12.2023/299). The study was registered on ClinicalTrials.gov with the identifier NCT06168747.

Consent to Participate Written informed consent was obtained from all patients.

Consent for Publication All authors have checked the text uploaded to the system and agreed that it should be uploaded to the system as the final text.

Competing Interests The authors declare no competing interests.

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