Research Article

Effects of Wrist Support Types on Grip Strength, Stability, Muscle Fatigue, and Muscle Activity During Static and Dynamic Functional Tasks

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Abstract

Purpose: This study aimed to investigate the effects of sleeve and wrap wrist supports on grip strength, stability, muscle activation, and muscle fatigue in healthy adults.
Methods: Forty-four healthy adults performed four functional tasks—Wrist Laser Stability Test, Cup Holding Test, Dart Throwing Accuracy Test, and Hammer Rotation Test—under no support, sleeve, and wrap conditions. Grip strength, RMS, and MDF were analyzed using paired and independent t-tests.
Results: Wrist wrap significantly improved grip strength and performance in dynamic tasks, while the sleeve offered greater benefits in static stability. MDF increased, indicating enhanced fatigue resistance, and RMS decreased, suggesting more efficient activation. These findings show that functional effects of wrist supports differ by type and task, underscoring the importance of individualized selection for rehabilitation, sports, and occupational applications.
Conclusions: The effects of wrist supports vary by type and task, indicating their use should be tailored to specific functional goals in rehabilitation, sports, and occupational contexts.

Keywords: Wrist wrap, Sleeve, Grip strength, Stability, RMS, MDF.

I. Introduction

Wrist supports are widely used as effective devices to enhance wrist stability, facilitate functional recovery, and protect against external impacts or excessive movements. Functional wrist–hand orthoses (WHO), also referred to as “working orthoses,” are applied not only in the conservative management of acute injuries or chronic disorders but also in occupational and sports settings to reduce wrist strain [1,2]. In particular, wrist supports help compensate for wrist instability and prevent cumulative fatigue or injuries caused by repetitive hand use. These devices can generally be categorized into compression sleeves and adjustable wraps, each providing different levels of mechanical stability and compression. For example, in the conservative treatment of wrist musculoskeletal injuries, immobilization techniques are often employed, with wrist orthoses commonly used to maintain the wrist in a neutral position [3]. Nevertheless, wrist supports are often prescribed or used without sufficient consideration of their specific structural characteristics.

A thorough understanding of the anatomical and functional characteristics of the wrist joint is essential for the proper application of wrist supports. The wrist is a complex structure that connects the hand to the forearm and plays a critical role in maintaining both stability and mobility through the interaction of muscles, ligaments, and other supporting structures. Static and dynamic wrist activities are regarded as crucial functional tasks in both daily living and rehabilitation [4]. Static activities demand support and stability to maintain posture, while dynamic activities emphasize active movement and joint mobility. The Dart Thrower’s Movement, for instance, reflects the functional range of motion of the wrist and is frequently used as an indicator of performance in daily tasks [5]. Moreover, research in patients with severe stroke has demonstrated that static stretching protocols effectively reduce wrist spasticity [6].

Functional activities involving the wrist often require high levels of grip strength, a key factor closely related to hand muscle strength. Maximum grip force is typically produced when the wrist is extended at 15–30°, and wrist supports may assist in maintaining this optimal alignment [1]. However, some studies have reported that wrist supports do not significantly affect maximal grip strength or dynamic grip endurance [7]. These inconsistent findings suggest that the effects of wrist supports may vary depending on the type of activity and user characteristics. Notably, grip strength is particularly critical in older adults, as its decline is strongly associated with loss of independence. Epidemiological evidence has demonstrated that reduced grip strength in healthy adults predicts functional limitations, disability risk, and even all-cause mortality in later life [8].

Wrist stability is determined by the integration of joint position sense and muscle co-activation, with co-contraction of flexors and extensors playing a central role in resisting internal or external instability [9]. The use of wrist supports may enhance this stability by facilitating such co-contraction, thereby improving task accuracy and consistency. During repetitive hand use or physical activities, continuous loading of the wrist often induces muscle fatigue, which can compromise function and provoke compensatory muscle activation [10]. Wrist supports may alleviate fatigue accumulation by providing mechanical support and consistent compression, thereby enabling sustained wrist use [11]. Beyond fatigue, supports have also been shown to influence muscle activity. By reducing unnecessary muscle tension during functional tasks, they may promote more efficient movement patterns [12,13].

Recent evidence has increasingly highlighted the positive contributions of wrist supports to functional performance. For instance, wrist support use has been associated with reduced extensor muscle activity, alleviated pain, and improved grip force [14]. Moreover, cylindrical forearm braces were reported to decrease muscle activity more effectively than pneumatic supports [15]. Additional studies have shown that wrist flexor and extensor activation patterns vary with movement direction, underscoring the physiological basis of brace-induced modulation [16]. Parallel evidence from lower-limb orthoses has also demonstrated improvements in gait stability and balance in healthy adults [17], suggesting potential applicability to wrist stability as well. Similarly, prolonged tasks such as typing have been shown to benefit from wrist supports, with reductions in muscle fatigue achieved through external support [11]. Collectively, these findings indicate that wrist supports can influence muscle activity, stability, and fatigue, though their effects may vary depending on type and context.

Nevertheless, methodological inconsistencies in prior studies have limited the generalizability of findings. Few investigations have comprehensively analyzed the effects of wrist supports on grip strength, stability, fatigue, and muscle activity across both static and dynamic tasks. For example, while some studies found no significant effects of wrist wraps on maximal grip strength or endurance [7], others reported that certain forearm bands may even exacerbate wrist extensor fatigue [18]. Although studies on lower-limb orthoses have provided evidence of mechanical and functional benefits [1], research focused on the wrist remains insufficient. These mixed results highlight the ongoing debate regarding the functional efficacy of wrist supports and emphasize the need for rigorous comparative analyses.

Therefore, the present study aims to investigate the effects of two types of wrist supports—sleeves and wraps—on grip strength, stability, muscle fatigue, and muscle activity during static and dynamic functional tasks. By elucidating the mechanical and biomechanical contributions of these supports, this study seeks to provide evidence-based guidance for wrist rehabilitation and for optimizing performance in occupational and athletic settings.

II. Materials and Methods

2.1. Participants

This study was conducted with forty-four healthy male and female participants in their twenties, all enrolled at S University located in City A. Participants were randomly assigned, using a computer-generated randomization table, to either the wrist wrap group (n = 22) or the wrist sleeve group (n = 22). All participants first performed the designated tasks without any wrist support, and subsequently repeated the same tasks while wearing the wrist support assigned to their group.

Inclusion criteria were as follows: individuals with no functional limitations of the wrist joint, possessing a normal range of motion; those able to freely move their wrist across various angles; individuals capable of performing both static and dynamic tasks while wearing a wrist support; and those able to fully understand and comply with the researcher's instructions. Exclusion criteria included a history of wrist disorders or prior wrist-related surgery, as well as musculoskeletal or neurological conditions such as muscle or ligament injuries. Prior to participation, all individuals received a detailed explanation of the study objectives and procedures, and written informed consent was obtained from each participant.

Table1. General Characteristics of Participants

	Wrap	Sleeve
Age(years)	20.91 ±1.19	20.19 ±1.19
Height(cm)	170.73 ±8.50	167.14 ±7.69
Weight(kg)	66.55 ±12.23	66.18 ±14.55
BMI	22.64 ±2.57	23.44 ±3.38

2.2. Experimental Design and Procedures

This study employed a repeated-measures design, and each participant took part in two experimental sessions separated by a one-week interval. The experiments were conducted individually in Laboratory Room 104 of the College of Health and Medical Sciences at S University.

In the first session, participants performed wrist-related functional tasks without wearing any wrist support. In the second session, they repeated the same tasks while wearing the wrist support (either sleeve or wrap) to which they had been randomly assigned as part of the experimental or control group. Each experimental session consisted of four functional tasks administered in a fixed order, with a three-minute rest period provided between tasks.

Figure 1. Wrap

Figure 2. Sleeve

2.2.1 Static Test

The static tests consisted of the Wrist Laser Stability Test and the Static Cup Hold Test. In the Wrist Laser Stability Test, participants were instructed to maintain accurate targeting of a central point located 2 meters away using a laser pointer attached to the wrist for 30 seconds. This task was designed to assess fine motor control and static stability of the hand and wrist, and the duration of time during which the laser deviated from the target was quantitatively recorded through video analysis.

The Static Cup Hold Test required participants to hold a beaker filled with 1 liter of water horizontally for 60 seconds while maintaining the shoulder flexed at 90° and the elbow fully extended. This task was used to evaluate wrist static stability and supporting capacity, with the amount of water spilled (ml) determined by measuring the remaining volume after the test, serving as a quantitative outcome measure.

Electromyographic (EMG) data were collected during both static tests.

2.2.2 Dynamic Test

The dynamic tests consisted of the Hammer Rotation Test and the Dart Thrower's Movement Test. In the Dart Thrower's Movement Test, participants threw a dart ten times toward a target located 2 meters away. The number of successful hits out of ten attempts was recorded as the outcome measure. This task was employed to assess wrist dynamic accuracy and motor coordination [5].

In the Hammer Rotation Test, participants were instructed to continuously rotate a rubber hammer clockwise for 30 seconds using only the wrist while keeping the forearm fixed. This task was designed to evaluate dynamic stability and motor control of the wrist, and the number of rotations completed within 30 seconds was recorded to analyze the consistency of wrist movement. Electromyographic (EMG) data were collected during both dynamic tests.

Figure 3. Wrist laser stability test

Figure 4. Static cup hold test

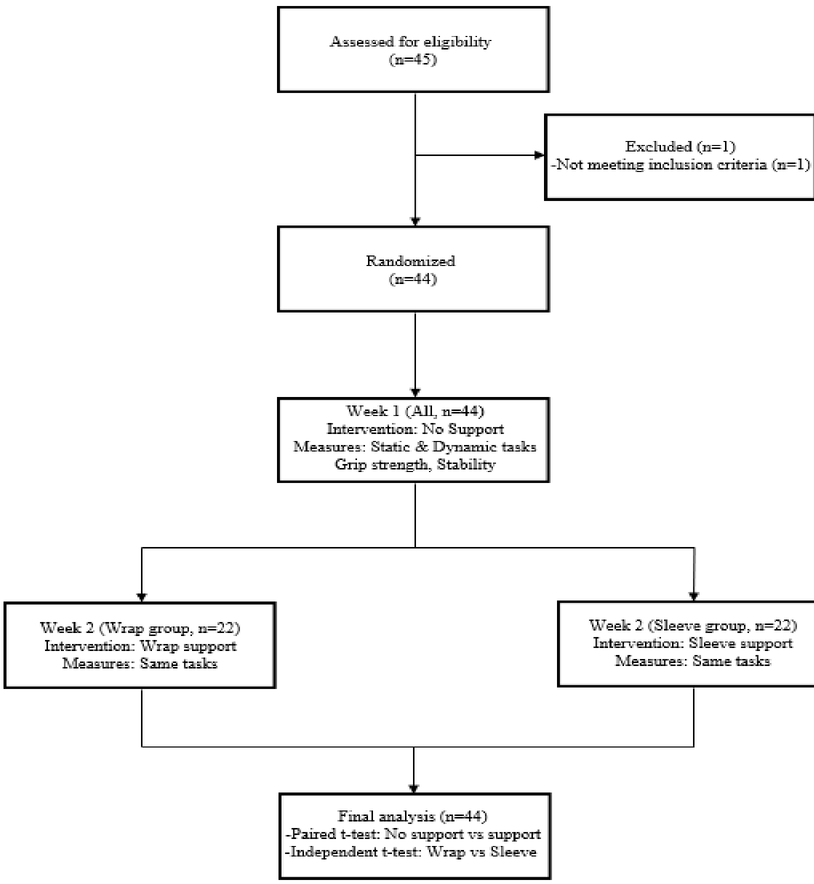
Figure 5. Dart thrower's movement test

Figure 6. Hammer rotation test

2.2.3 Grip strength Test

The Grip Strength Test was conducted to evaluate maximal hand power. Prior to the experimental tasks, participants performed the grip strength assessment while maintaining the wrist in a neutral position and the testing arm adducted alongside the trunk. Three consecutive trials were performed at each measurement point, and the highest value among the three trials was used for analysis.

Figure 7. Experimental Procedure



2.3. Apparatus and EMG Settings

To measure muscle activity and muscle fatigue, the BTS FREEEMG 1000 system (BTS Bioengineering, Italy) was employed. This device is a wireless surface electromyography (sEMG) system that does not restrict natural movement and allows real-time data acquisition, thereby providing high ecological validity.

For EMG measurements, electrodes were placed on two muscles. For the Flexor Carpi Radialis (FCR), electrodes were attached to the medial aspect of the forearm, approximately 4 cm distal to the medial epicondyle of the humerus, oriented toward the wrist. For the Extensor Carpi Radialis Longus (ECRL), electrodes were positioned on the lateral aspect of the forearm, approximately 5–7 cm distal to the lateral epicondyle of the humerus, also directed toward the wrist. All electrodes were placed parallel to the muscle fiber orientation, with an interelectrode distance of 2 cm. A reference electrode was attached to a bony area of the forearm.

2.4. Outcome Measures and Analysis

The primary outcome measures of this study included muscle activation, muscle fatigue, grip strength, and stability. Muscle activation was quantified by analyzing EMG data collected from the flexor carpi radialis (FCR) and extensor carpi radialis longus (ECRL) using root mean square (RMS) values to represent the intensity of muscle contraction. Muscle fatigue was assessed by evaluating changes in the median frequency (MDF), which reflected the degree of fatigue accumulation before and after the tasks. Grip strength was measured using a hand dynamometer, with three trials performed at each time point, and the highest value was recorded. Measurements were obtained both before the static tasks and after the dynamic tasks to analyze changes associated with wrist support use. Stability was assessed using task-specific indicators. In the Wrist Laser Stability Test, the time deviating from the target was recorded. In the Static Cup Holding Test, the amount of water spilled (mL) was measured. In the Dart Throwing Accuracy Test, the number of successful hits was used to evaluate dynamic wrist accuracy. In the Hammer Rotation Test, the number of wrist rotations was compared to assess motor stability.

2.5. Statistical Analysis

Statistical analyses were performed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA), with the level of significance set at $p < 0.05$ for all tests. The normality of distribution for all variables was verified using the Shapiro–Wilk test. Independent-samples t-tests were conducted to compare differences between the wrist wrap group and the wrist sleeve group, while paired-samples t-tests were used to assess within-group differences before and after wrist support application.

III. Results

Analysis of functional task performance revealed distinct patterns of change depending on task type and support condition.

For Wrist Laser Stability, both the wrap and sleeve groups showed significant post-intervention decreases (wrap: p < 0.01**, sleeve: p < 0.01**), with no significant difference between groups (p = 0.06). In the Static Cup Hold Test, the decrease was not significant in the wrap group (p = 0.07), whereas a significant reduction was observed in the sleeve group (p < 0.01**). Between-group comparisons indicated a greater reduction in the sleeve group, yielding a significant difference (p = 0.02*). For Dart Throwing, no significant change was found in the wrap group (p = 0.79), while the sleeve group showed a significant decrease (p = 0.03*); however, between-group differences were not significant (p = 0.79). In Hammer Rotation, the wrap group demonstrated a significant post-intervention increase (p < 0.01**), whereas the sleeve group showed a significant decrease (p < 0.01**), and the between-group comparison also revealed a significant difference (p < 0.01**). For Grip Strength, the wrap group exhibited a significant increase (p < 0.01**), while the sleeve group demonstrated a significant decrease (p < 0.01**), with the between-group comparison likewise showing a significant difference (p < 0.01**).

Table 2. Stability Outcomes from Functional Task Assessment (Paired and Independent t-test)

		Pre(M±SD)	Post(M±SD)	t	p
Wrist laser stability (s)	wrap	5.42±1.71	4.95±1.35	3.141	< 0.01**
	sleeve	5.05±1.97	4.12±1.44	4.418	< 0.01**
	t		1.948		
	p		0.06		
Static cup hold test (ml)	wrap	6.68±5.48	4.23±1.82	1.925	0.07
	sleeve	8.82±6.39	2.82±1.89	4.074	< 0.01**
	t		2.514		
	p		0.02*		
Dart throwing (n)	wrap	4.27±1.98	4.45±2.38	-0.266	0.79
	sleeve	5.09±2.28	4.27±2.07	2.409	0.03*
	t		0.270		
	p		0.79		
Hammer rotation (reps/30 s)	wrap	30.64±6.65	34.50±6.08	-5.750	< 0.01**
	sleeve	30.64±7.00	26.64±6.70	6.481	< 0.01**
	t		4.072		
	p		< 0.01**		
Grip strength (kgf)	wrap	30.45±7.80	33.68±8.75	-6.807	< 0.01**
	sleeve	30.27±7.23	26.18±7.86	8.171	< 0.01**
	t		2.989		

p		< 0.01**

n = number of successful hits out of 10 attempts. Values are presented as mean ± SD; * p < 0.05, ** p < 0.01 (two-tailed); p-values rounded to two decimals, with 0.001 ≤ p < 0.01 reported as p < 0.01 and p < 0.001 reported as p < 0.001.

Analysis of muscle fatigue (MDF) revealed distinct differences according to task type and support condition.

For Wrist Laser Stability, the wrap group showed an increase in the FCR compared with baseline, although this was not statistically significant (p = 0.06), whereas the ECRL exhibited a significant post-intervention increase (p < 0.01**). In the sleeve group, both the FCR (p < 0.01**) and ECRL (p < 0.01**) significantly increased; however, no significant between-group differences were observed (p > 0.05*). In the Static Cup Hold Test, the wrap group demonstrated significant increases in both the FCR (p < 0.01**) and ECRL (p < 0.01**). In the sleeve group, the FCR showed a significant increase (p = 0.03*), while the ECRL did not reach significance (p = 0.50). Between-group comparisons indicated no difference in the FCR (p = 0.40), but a significant difference was found for the ECRL (p < 0.01**). In Dart Throwing, the wrap group showed significant increases in both the FCR (p < 0.01**) and ECRL (p < 0.01**). The sleeve group also demonstrated significant post-intervention increases in the FCR (p < 0.01**) and ECRL (p < 0.01**). Between-group comparisons revealed significant differences in both the FCR (p < 0.01**) and ECRL (p = 0.04*). For Hammer Rotation, the wrap group exhibited a significant post-intervention increase in the FCR (p < 0.01**) and a significant decrease in the ECRL (p = 0.05*). In contrast, the sleeve group showed significant increases in both the FCR (p < 0.01**) and ECRL (p < 0.01**). Between-group comparisons revealed no significant difference in the FCR (p = 0.16), but a significant difference was observed in the ECRL (p < 0.01**).

Table 3. MDF Outcomes during Functional Tasks (Paired and Independent t-test)

		muscle	Pre(M±SD)	Post(M±SD)	t	p
Wrist laser stability	wrap	FCR	97.28±25.90	115.36±30.06	-1.996	0.059
		ECRL	80.15±25.30	93.15±24.38	-4.772	< 0.01**
	sleeve	FCR	98.50±28.89	119.96±27.62	-4.395	< 0.01**
		ECRL	77.29±21.41	99.41±33.72	-4.050	< 0.01**
	t	FCR		-0.529		
		ECRL		-0.706		
	p	FCR		0.60		
		ECRL		0.48		
Static cup hold test	wrap	FCR	72.79±13.33	84.09±16.51	-6.399	< 0.01**
		ECRL	59.23±14.82	76.60±15.86	-3.561	< 0.01**
	sleeve	FCR	85.62±18.25	88.59±18.78	-2.284	0.03*
		ECRL	147.77±20.01	153.33±27.01	-0.688	0.50
	t	FCR		-0.844		
		ECRL		-11.487		
	p	FCR		0.40		
		ECRL		< 0.01**		
Dart throwing	wrap	FCR	55.82±11.80	63.32±12.81	-3.192	< 0.01**
		ECRL	64.47±15.41	76.99±12.16	-7.262	< 0.01**
	sleeve	FCR	67.09±12.52	76.38±12.05	-5.652	< 0.01**
		ECRL	74.35±6.62	83.89±9.13	-3.682	< 0.01**
	t	FCR		-3.482		
		ECRL		-2.126		
	p	FCR		< 0.01**		
		ECRL		0.04*		

Hammer rotation	wrap	FCR	67.51±10.15	76.12±9.62	-7.387	< 0.01**
		ECRL	65.07±10.10	58.97±12.11	2.108	0.05*
	sleeve	FCR	75.66±12.27	81.63±12.86	-4.873	< 0.01**
		ECRL	69.59±13.62	81.74±12.55	-5.454	< 0.01**
	t	FCR		-1.609		
		ECRL		-6.121		
	p	FCR		0.16		
		ECRL		< 0.01**		

MDF values are expressed in Hz. Values are presented as mean ± SD; * p < 0.05, ** p < 0.01 (two-tailed); p-values rounded to two decimals, with 0.001 ≤ p < 0.01 reported as p < 0.01 and p < 0.001 reported as p < 0.001.

Analysis of muscle activation (RMS) demonstrated differential changes depending on task type and support condition.

For Wrist Laser Stability, no significant change was observed in the FCR of the wrap group (p = 0.11), whereas the ECRL showed a significant post-intervention decrease (p < 0.01**). In the sleeve group, both the FCR (p < 0.01**) and ECRL (p < 0.01**) decreased significantly. Between-group comparisons revealed significant differences in both muscles (FCR: p < 0.01**, ECRL: p < 0.01**). In the Static Cup Hold Test, both the FCR and ECRL significantly decreased in the wrap group (FCR: p < 0.01**, ECRL: p < 0.01**). Similarly, in the sleeve group, significant reductions were also observed in the FCR (p = 0.03*) and ECRL (p = 0.03*). Between-group comparisons confirmed significant differences for both muscles (FCR: p < 0.01**, ECRL: p < 0.01**). For Dart Throwing, the wrap group showed a significant post-intervention increase in the FCR (p < 0.01**), whereas no significant change was detected in the ECRL (p = 0.99). In contrast, the sleeve group exhibited significant decreases in both the FCR (p < 0.01**) and ECRL (p < 0.01**). Between-group analyses demonstrated significant differences in both muscles (FCR: p < 0.01**, ECRL: p < 0.01**). In Hammer Rotation, the wrap group showed significant decreases in both the FCR (p = 0.04*) and ECRL (p = 0.02*). Conversely, in the sleeve group, neither the FCR (p = 0.06) nor the ECRL (p = 0.05) showed significant changes. Between-group comparisons revealed significant differences in both muscles (FCR: p < 0.01**, ECRL: p = 0.02*).

Table 4. RMS Outcomes during Functional Tasks (Paired and Independent t-test)

		muscle	Pre(M±SD)	Post(M±SD)	t	p
Wrist laser stability	wrap	FCR	20.69±10.72	11.26±3.62	1.693	0.11
		ECRL	19.91±8.88	16.20±4.37	-6.399	< 0.01**
	sleeve	FCR	48.83±29.20	37.67±15.65	3.792	< 0.01**
		ECRL	70.44±37.08	48.07±24.53	7.966	< 0.01**
	t	FCR		-7.705		
		ECRL		-5.997		
	p	FCR		< 0.01**		
		ECRL		< 0.01**		
Static cup hold test	wrap	FCR	77.35±39.68	45.84±19.84	7.449	< 0.01**
		ECRL	99.18±18.71	71.87±18.43	7.289	< 0.01**
	sleeve	FCR	94.97±14.11	87.43±21.25	2.276	0.03*
		ECRL	123.14±10.78	115.04±18.01	2.292	0.03*
	t	FCR		-6.709		
		ECRL		-7.857		
	p	FCR		< 0.01**		
		ECRL		< 0.01**		
Dart throwing	wrap	FCR	41.92±11.17	59.06±18.21	-4.003	< 0.01**
		ECRL	62.54±15.35	62.53±21.83	0.001	0.99
	sleeve	FCR	44.50±13.52	44.91±13.79	-3.146	< 0.01**
		ECRL	89.33±9.63	111.13±17.65	-4.891	< 0.01**
	t	FCR		2.905		

		ECRL		-8.118		
	p	FCR		< 0.01**		
		ECRL		< 0.01**		
Hammer rotation	wrap	FCR	120.61±17.23	125.44±18.48	-2.169	0.04*
		ECRL	147.92±22.75	154.58±26.15	-2.512	0.02*
	sleeve	FCR	115.61±19.67	108.80±20.50	2.004	0.06
		ECRL	141.64±20.96	135.94±24.27	2.043	0.05
	t	FCR		2.828		
		ECRL		2.449		
	p	FCR		< 0.01**		
		ECRL		0.02*		

RMS values are expressed in μV. Values are presented as mean ± SD; * p < 0.05, ** p < 0.01 (two-tailed); p-values rounded to two decimals, with 0.001 ≤ p < 0.01 reported as p < 0.01 and p < 0.001 reported as p < 0.001.

IV. Discussion

This study evaluated the effects of wrist support devices on wrist function by analyzing grip strength, stability during functional tasks, muscle fatigue, and muscle activation. The results varied depending on task demands and muscle characteristics, with the structural differences of the supports emerging as a key factor.

Regarding grip strength, the wrap group exhibited a significant post-intervention increase, whereas the sleeve group showed a significant decrease. James et al.(2021) reported that wrist wraps enhanced grip strength in power-related activities [19], while Stern compared four types of wrist orthoses and demonstrated that device type can exert contrasting influences on grip strength and dexterity [20]. This can be interpreted as the wrap providing localized support to the wrist while preserving the movements necessary for force exertion, whereas the sleeve envelops the palm and forearm, thereby restricting free motion. In sports settings, the advantage of wraps may become particularly pronounced in situations requiring maximal, instantaneous force output. Conversely, sleeves may be more suitable for patients in the early stages of rehabilitation or in contexts where maintaining a stable posture is essential. Thus, the choice of support should not be based on a simple comparison but tailored to the individual's goals and circumstances.

In functional tasks, overall stability improved in the laser and cup-holding tests, while performance outcomes in the dart and hammer tasks diverged depending on the type of support. Popp et al.(2023) reported that wrist fixation and stabilization may enhance stability but reduce precision [9], and Hirata et al.(2024) similarly observed that increased stability could coincide with reduced fine control in upper limb function and activities of daily living [21]. Consistent with these findings, the present study indicated that wraps maintained joint alignment while allowing free movement of the fingers and forearm, thereby facilitating performance in tasks requiring force exertion, such as hammer rotation and grip strength tests. In contrast, sleeves restricted wrist rotation and fine joint mobility, resulting in decreased performance in precision-demanding tasks such as dart throwing. These findings suggest that supports are not merely devices that enhance stability, but rather tools that modulate the balance between freedom of motion and precision depending on task requirements. Accordingly, in sports or occupational environments, a more nuanced strategy is needed in which the type of support is selected according to task characteristics.

Muscle fatigue, assessed by median frequency (MDF), has been reported to vary depending on wrist posture and grip type. Finneran et al.(2013) demonstrated that fatigue accumulation and endurance of forearm muscles differ substantially across wrist angles and grip strategies [22], while Johansson reported that wrist orthosis use can alter fatigue accumulation patterns and, under certain conditions, contribute to the preservation of endurance [23]. In line with these findings, the present study showed that post-task MDF values increased significantly in several tasks and muscles, indicating enhanced resistance to fatigue. This suggests that wearing supports reduced unnecessary co-contractions, improved energy efficiency, and consequently delayed fatigue accumulation. Specifically, wraps provided localized stabilization that preserved activation required for dynamic tasks while suppressing unnecessary tension, whereas sleeves offered broad compression that reinforced static stability but imposed excessive restrictions in some dynamic tasks, thereby limiting fatigue-relieving effects. These results highlight that wrist supports contribute not only to immediate force exertion but also to sustained endurance during prolonged task performance, providing practical implications for preventing work-related musculoskeletal disorders.

Muscle activation, measured by root mean square (RMS), displayed marked task-specific differences. Jarque-Bou et al.(2024) reported that flexor–extensor activation patterns vary significantly according to task characteristics and force levels in everyday grip activities [24]. Sahoo et al.(2023) found that wrist extension orthoses reduce pain and induce EMG changes in specific muscles, thereby influencing functional performance [25]. Di Domizio et al.(2008) demonstrated that splinting alters forearm muscle activation and handgrip force output [26], while Beringer et al.(2020) showed that wrist posture alone can substantially affect extrinsic finger muscle activity [27]. The present findings align with this body of evidence: in the laser and cup-holding tasks, RMS decreased, reflecting suppression of unnecessary activation, whereas in the dart and hammer tasks, patterns diverged depending on support type. Wraps produced localized pressure, leading to selective reductions in muscles such as the flexor carpi radialis (FCR), thereby preserving activation needed for dynamic performance. Conversely, sleeves induced broader reductions in both the FCR and extensor carpi radialis longus (ECRL), which appeared to impair performance in precision-demanding tasks. These findings suggest that wrist supports not only reduce muscular tension but may also influence neuromuscular control and motor learning processes. Future studies should examine the long-term effects of support use on neural adaptation and rehabilitation outcomes.

Taken together, MDF and RMS results indicate that task demands, muscle roles, and support structures interact to produce distinct outcomes. Mannella et al.(2022) showed that during isometric handgrip, wrist perturbations alter flexor–extensor activation and intermuscular coordination, thereby reducing efficiency [28]. Mao et al.(2023) demonstrated that EMG and fatigue indicators are highly sensitive to changes in task type and force level [29]. Van Petten et al.(2015) confirmed that structural differences among wrist orthoses directly affect flexor–extensor activation patterns [12]. The fact that group differences in MDF and RMS were significant only in certain tasks suggests that outcomes depend less on mere presence or absence of supports, and more on the interaction between task demands, muscle roles, and orthosis design. Therefore, interpreting the effects of supports requires an integrative approach that considers multiple indicators—including fatigue, activation, and precision—rather than relying on a single measure. This underscores the need for more refined evaluation tools in both clinical and research contexts.

In summary, wraps demonstrated advantages in force generation and dynamic task performance, whereas sleeves proved more effective in situations requiring static stability. These differential effects highlight that the functional benefits of wrist supports are determined by their structural features in interaction with task characteristics. Such findings are consistent with prior research emphasizing that the design and prescription of wrist–hand orthoses should be tailored to the intended activity [30,31]. Moreover, reports indicating that wrist positioning significantly influences grip endurance and grip strength [32] reinforce the necessity of carefully considering joint alignment and range of motion when prescribing or designing orthoses. Accordingly, in clinical and sports settings, individualized strategies based on patients' or athletes' goals and functional demands are essential. Beyond these domains, wrist supports may also serve as valuable tools to reduce musculoskeletal strain in occupational environments with repetitive tasks. Thus, this study suggests multidisciplinary applications spanning medical, sports, and industrial fields.

This study has several limitations. First, the participants were limited to healthy adults, restricting generalization to populations such as patients with wrist injuries or older adults. Second, wrist function was evaluated through four tasks—laser pointing, cup holding, dart throwing, and hammer rotation—which do not fully represent the wide range of activities encountered in sports or occupational settings. Third, only short-term effects of support use were analyzed, leaving potential long-term adaptations in muscle activation patterns and fatigue accumulation unaddressed. Fourth, all participants performed the no-support condition first for baseline comparison, which prevented complete control of order effects; consequently, fatigue or learning effects may have influenced some results. Finally, the wraps and sleeves used in this study were limited to specific commercial products, restricting the generalizability of the findings to other types of wrist supports.

V. Conclusions

In conclusion, this study demonstrated that the functional effects of wrist supports differ depending on support type and task demands. Wrist wraps were particularly effective in enhancing grip strength and improving performance in dynamic activities, while sleeves offered greater advantages in maintaining static stability. These differential outcomes emphasize that wrist supports should not be applied uniformly but instead selected according to the specific functional goals of the user. Such an individualized approach has important implications for rehabilitation, sports performance, and occupational applications, where task requirements and performance objectives vary considerably.

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