Importance of good working gloves - ErgoSleeve in validating the gloves and measuring arm muscle load

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Abstract:

Project scope. Good working gloves help in maintaining firm grip and lighten manual handling and lifting work. In hand intensive work arm muscle load evaluation by EMG can be used in choosing the best glove to the industry. We compared different models of working gloves on forearm muscle EMG activation levels in hold and release test with cylinder shaped object, screwdriver and handling grocery store-specific items.

Design. Several types of working gloves and bare hand were used in hold and release test with a cylinder type of glass object, a torsion movement with a screwdriver and hold and release test with grocery store items. ErgoSleeve (Myontec, Finland) was used for measuring wireless wrist flexor and extensor EMG, integrating analytics of the collected data with video in ErgoLink software. Arm muscle load was normalised to maximum isometric load (MVC) of hand flexors and extensors.

Results. In part one screwdriver torsion test Tegera 9102 showed the lightest forearm muscle activation level (13,6 %MVCmax) compared to the Tegera 325 (20,9 %MVCmax) and Tegera 8801 (20,3 %MVCmax) and bare hand (19,4 %MVCmax). There were notable differences in hold and release test between those gloves.

With another type of gloves and grocery store-specific items, mean combined flexor and extensor EMG in hold and release test varied from 8,3 %MVCmax to 10.2 %MVCmax (SD 3,3-5,4). The EMG difference between the gloves was greatest (9,5 %MVCmax -17,1 %MVCmax) in heavy 1,5 liter soft drink bottle compared to the light bag of screws (2,6 %MVCmax. 2,9%MVCmax).

Discussion. Arm muscle load differences in grip hold and release test between the gloves were notable, one of the gloves showing an extreme value of even 35% lower EMG activity level compared to another tested clove and 30% lower compared to task with bare hand in hold and release test. The properties of the gloves have notable effect on forearm muscle activity during manual material handling and ErgoSleeve helps choosing the most ergonomic glove for the tasks. The firm working glove grip becomes extremely important in reducing hand fatigue in long daily use.

Conclusions. ErgoSleeve provides fast tool in evaluating ergonomic task-specific gloves which provide superior hand grip, diminish product damage and enhance productivity.

Keywords: EMG, grip, hand intensive work, manual handling

Introduction

Gloves at work are worn for many reasons. In hand intensive work, the ideal work glove reduces grip strength requirements in lifting carrying and handling the objects. Over time, greater grip forces usually lead to musculoskeletal disorders of hands and arms.

The purpose of this practitioners' example was to measure forearm muscle load in two types of experiments. First, three types of gloves were tested in hold and release protocol and torsion movement with a screwdriver. Second, hold and release test was performed with typical grocery store items.

Methodology

ErgoSleeve (Myontec, Finland) was used for forearm flexor and extensor muscle electric activity (EMG) measurement. The smartwear has textile sensors across the proximal part of wrist flexor (2 cm x 8 cm wide) and extensor muscle groups (3 cm x 10 cm). Measurement preparations consist of moistening the sensors with tap water and skin with paraffin-free moisturizer. EMG activity was collected to a data logger (MCell) and controlled remotely by an ErgoMobile application installed in mobile phone and accompanied with video recording.

Maximum voluntary contraction tests (MVC) for wrist flexors and extensors were performed according to the protocol of Akinnola at al. (2020).

Fig 1. ErgoSleeve (Myontec. Finland) is an elastic smartwear with textile sensors in the inner layer of the product. Sensors measure wrist flexor and extensor muscle groups.

Measured gloves in part 1 test were Tegera 235, Tegera 8801 Infinity, and Tegera 9102, all by Ejendals AB, Sweden. In part 2 with the grocery store item testing the gloves were Tegera 8807, Tegera 8815, Tegera 906, Maxifoam 34-800 and nitrile gloves.

The movement testing was performed in sitting position in standard office table. Male subjects (N=2) were on average 44 years, average height 179 cm and weight 80kg. Holding test sample bottle (1 kg) and the grip was gradually lightened until the bottle dropped on the table. The muscle load parameter was the test point just before losing the grip from the bottle. Turning torque was adjusted with a screwdriver to trigger release at 3 levels (0,5Nm, 1.0 Nm, 1.5 Nm).

Each test position was standardized by object placing and lifting height. Test repetitions with each glove was performed in randomized order. An average load was measured from three trials on each test.

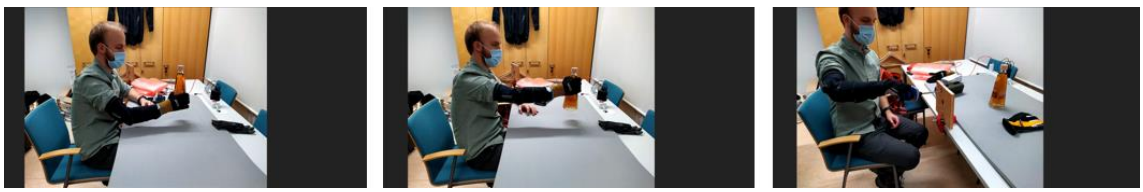

Figure 2. Testing movements consist of static grip to slow grip release (at wide position on left), (at narrow position on middle) and torsion movement with MicroClick torque screwdriver (on right).

The EMG data was recorded at a 1000Hz sampling frequency and filtered, rectified and averaged with bandwidth of 25Hz in ErgoLink software. Signal from the wrist flexors and extensors were averaged and presented as absolute µV mean values. Data was normalized to the MVCmax value over 1 s window, when the signal was greatest, averaged across the channels and reported as %MVCmax for the muscles tested.

Results

The wide grip EMG level (%MVCmax) varied from 5,0 to 6,0, narrow grip from 4,5 to 5,0.

In torsion test, EMG level (%MVCmax) in Tegera 325 glove was 25,0, 33,9 and 35,5 during the maximum torque of <1Nm, 1,5Nm and >2 Nm, respectively. Similarly, the Tegera 8801 resulted in 26,0, 27,0 and 39,0 EMG levels (%MVCmax). The Tegera 9102 glove showed smallest EMG level (%MVCmax) in <1Nm 16,3 %MVCmax, in 1,5 Nm 19,3 %MVCmax and in 2Nm torque 22,0 %MVCmax. (Table 1).

In combined wrist flexor and extensor EMG activation levels, Tegera 325 resulted in 20,9 %MVCmax, Tegera 8801 in 20,3%MVCmax and Tegera 9102 in 13,6 %MVCmax. The Tegera 9102 showed lower EMG levels in heavy duties compared to the other glove models. In light work there were no significant differences between the glove types in forearm EMG levels.

Glove comparison - Part 1

Type of movement	Glove models	TEGERA 325	TEGERA 8801	TEGERA 9102	STD	Bare hand/dry
		Wrist muscles				
		Loading % in relation to MVC				
1. Wide grip		5,3	5,0	6,0	0,5	13,5
2. Narrow grip		5,0	4,5	4,5	0,3	10,5
3. Torsion 1 (Max torque ~ 0,5 Nm)		25,0	26,0	16,3	5,4	17,5
4. Torsion 2 (Max torque ~ 1 Nm)		33,8	27,0	19,3	7,3	23,5
5. Torsion 3 (Max torque ~ 1,5 Nm)		35,5	39,0	22,0	9,0	32,0
Forearm in total		**20,9**	**20,3**	**13,6**	4,1	**19,4**
	STD	14,9	15,1	7,9		8,6

Table 1. Comparison of three types of Tegera gloves and hand grip EMG activity level (%MVCmax).

In the hold and release of grocery store items the nitril glove showed highest muscle activities, in mean 10,2 %MVCmax over all the measured items. The lightest muscle load was measured with Maxifoam (8,3 %MVCmax) and Tegera 906 (8,6 %MVCmax). Table 2,

Glove comparison - Part 2

Type of movement	Wrist muscles Loading % in relation to MVC Glove models	Nitril	MAXIFOAM	TEGERA 8807	TEGERA 8815	TEGERA 906	STD	Bare hand/dry
1. Soda 1,5 l		17,1	9,5	15,3	14,4	10,4	3,1	10,6
2. Aluminium can 0,5 l		7,5	7,7	7,8	7,2	7,8	0,2	7,5
3. 6-pack beer container		12,8	11,3	10,9	11,3	11,6	0,6	11,9
4. Flour, 1 kg		10,7	10,0	9,8	9,7	10,5	2,9	17,1
5. Small package of screws		2,9	2,8	2,8	2,8	2,6	0,1	2,8
Forearm in total		**10,2**	**8,3**	**9,3**	**9,1**	**8,6**		**10,0**
	STD	5,4	3,3	4,5	4,4	3,6		5,3

Table 2. Comparison of five types of gloves and hand grip EMG activity level (%MVCmax) during hold and release test.

Discussion

The test results in screwdriver torsion were consistent in showing remarkable lower muscle activity demands with Tegera 9102 compared to the two other glove models tested (Tegera 315 and Tegera 8801) in torsion demanding movement with the screwdriver. Particularly Tegera 9102 was 32% lighter than Tegera 8801 and 30% lighter than test procedure with bare hand. In hold and release test, there were no significant differences between the gloves.

The grocery store item test protocol showed that muscle load was greater with heavier objects. Object surface properties played also essential role in the movement strenuousness, flour bag was strenuous to lift with bare hands. The nitrile glove was the worst glove in almost every product lifting test.

Large reduction of glove type in grip strength have been found also in other experiments, such as 18% to 54% (Ricardo et al. 2016), 30% (Zhao et al, 2021) and 38% (Willms 2006). Thus, the important role of glove choice on forearm muscle activity levels is widely acknowledged. Testing the gloves in product development phase can be a marketing tool for glove companies. The industries consuming gloves tangle with the difficulty of choosing the right glove to the right work. ErgoSleeve is a fast tool to reveal the glove properties and lighten the manual material handling in hand intensive work.

Conclusions

Glove design and material type have clear effect on forearm muscle electric activity (EMG) particularly in torsion-type movement with screwdriver and in handling objects with variety of shapes and materials, e.g. grocery store items. The worst choice to do manual materials handling is to do it bare hand. Gloves at work are not only needed for protective purposes but also to reduce handgrip strength demands in manual handling.

References

Akinnola O.O., Vardakastani V., Kedgley A.E. (2020). Identifying tasks to elicit maximum voluntary contraction in the muscles of forearm. J ElectroMyography Kinesiol 55:102463.

Lanham S., (2011). The impact of gloves and simulated occupational tasks on handgrip strength in structural firefighters. Thesis Georgia Southern University.

Ricardo C., Patricia M., Augusto L. (2016). Hand grip strength analysis due to glove use in cleaning and cafeteria activities. Rev Cinec Salud vol 14(3) 379-396. .

Sharma L.K., Sain M.J., Meena M.L. (2022). Analyzing the effects of industrial protective glove's material on hand grip strength. Conference paper. Lecture notes in mechanical engineering. 16.Apr 2022.

Willms K.K. (2006). An examination of glove attributes and their respective contributions to force decrement and increased effort on power grip at maximal and submaximal levels. Thesis University of Waterloo, Canada.

Wirmer B.M., Mcdowell T.W., Xu X.S. et al. (2010). Effects of gloves on total grip strength applied to cylinder handles. Int J Ind Ergonomics 40(5)574-583.

Zhao C., Li K.W., Yi C. (2021). Assessment of work gloves in terms of the strengths of hand grip, one-handed carrying, and leg lifting. Appl Sci 11(8)2894.