TRIDHA
Journal of Clinical Cases & Reports
Volume 2025, Issue 4, 9 pages
https://doi.org/10.46619/joccr.2025.8-1189

www.tridhascholars.org

COMMENTARY

Grip-Strength Measurement for Impairment Assessment Using Telemedicine

Danny Baggett[1], Zach Griebel[1], Jerry Artz[1], Bruce Bolon[1], and John Alchemy[2*]

[1]*Department of Physics, Hamline University, Saint Paul MN, USA*

[2]*RateFast Corporation, Santa Rosa CA, USA*

Correspondence should be addressed to John Alchemy, RateFast Corporation, Santa Rosa CA, USA

Received: 9 September 2025; Accepted: 7 October 2025; Published: 17 October 2025

ABSTRACT

Telemedicine continues to adapt in order to increase the accessibility of healthcare to patients, yet some challenges remain. Many diagnostic tests are difficult to adapt to telemedicine since they require standardized instrumentation. The standard device that doctors use in their offices for grip-strength testing, for example, is a calibrated hand dynamometer. The accuracy of such measurements is essential when evaluating upper extremity injuries about impairment or functional loss. This research describes an alternative method to test grip strength without the use of a calibrated dynamometer, instead utilizing common household materials and a simple procedure. This method has been proven reliable and should increase patient accessibility to grip-strength evaluation for quantitative impairment rating and subsequent compensation. This research builds upon a previous pilot study published by Griebel, et al.

INTRODUCTION

This study aims to create a grip-strength test that can be performed at home using inexpensive, readily available materials. Doctor appointments can be difficult to schedule and visits to the hospital are often lengthy and expensive. According to a Pew Research poll of major problems in urban, suburban, and rural communities in 2018, "Nearly a quarter (23%) of Americans in rural areas say that access to good doctors and hospitals is a major problem in their community" [1]. Another Pew Research survey conducted in 2023 found that 64% of Americans surveyed say that the affordability of healthcare is a "very big problem," ranking 2nd among the 16 problems surveyed, above drug addiction (61%) and violent crime (59%) [2]. Virtual visits can remove these transportation barriers and expand availability to underserved patient populations [3,4]. While the benefits of telemedicine have been highlighted in recent publications, telemedicine visits have been shown to be as effective as in-person visits for more than 20 years [4-14]. The development of appropriate procedures using inexpensive, readily available materials can make it possible for patients to perform diagnostic tests at home that are as reliable as those performed at a doctor's office.

More than 40 states use the *American Medical Association Guides to the Evaluation of Permanent Impairment (AMA Guides)* as the standard for evaluating impairment and assigning impairment ratings used to determine workers' compensation [15]. In 2020 and 2021, the average total compensation for injuries to the hand, fingers, or wrist was $26,284 [16]. Accurate impairment rating is clearly important to injured workers, so any at-home method intended to replicate procedures performed in doctors' offices must provide results consistent with the in-office results.

To measure grip strength, the *AMA Guides* requires that patients use a handheld dynamometer, a tool typically only available in doctors' offices [15]. For this reason, grip strength cannot usually be tested virtually. This study proposes a suitable method for testing grip strength at home, using readily available materials. Alchemy, et al., have already created a novel method to test pinch strength at home using accessible materials [17]. The authors of this paper now aim to do the same for grip strength.

This study continues the pilot study in which multiple participants squeezed a horizontal water bottle, and the distance the water travelled was used to determine the grip strength [18]. To compare this novel method against the standard *AMA Guides* method, this study uses data collected via a Baseline Hydraulic Hand Dynamometer [19]. The pilot study had 38 participants, while the current study updates it with data from additional participants resulting in grip-strength measurements for 112 total participants. This population included at least 50 men and 50 women, which the authors felt was necessary to create a medically significant study.

PROCEDURE

Participants in this study were classified by gender, age, and hand dominance. No data was included that corresponded to hands that had prior injuries. All participants were required to sign Hamline University Institutional Review Board-approved consent forms to participate. A total of 112 volunteers (213 uninjured hands), 57 males, 53 females, and 2 non-binary individuals participated in the study with an age range from 13 to 79 years old.

The protocol established for this research experiment required each participant to perform five trials with one hand, then another five trials with the other (except in cases where the participant had an injured hand). A given trial involved first following the protocol described for the dynamometer, then the at-home protocol (described in Parts I and II, respectively, below), with around 30 seconds of rest in between each measurement. Alternating in this way was intended to prevent fatigue from affecting the results for one protocol more than those for the other.

It should be noted that occasionally a participant would say that a particular trial did not go well because they did not yet understand the technique of the dynamometer or water bottle. In such cases, the trial was redone and the faulty measurement was not used. There were also times that the water bottle visibly tilted upward resulting in a non-horizontal exit velocity. When this occurred, the result was not used, and the trial was redone with the participant instructed to keep the bottle flat.

As described previously, the purpose of this study is to establish an at-home protocol, using common household items, that would allow a patient to measure grip strength without the necessity of using a dynamometer. For this experiment, however, it is necessary to establish a correlation between the at-home measurement of the horizontal distance the water travels and the dynamometer reading. To do this, a relationship between the grip strength applied to the water bottle and the exit velocity of the water must be established.

Part I: Dynamometer Method Based on AMA Guides

The standard protocol to measure grip strength, as outlined in the *AMA Guides*, specifies the use of a calibrated hand dynamometer. This protocol directs a patient, or in this case a research participant, to have their shoulder neutral, elbow at 90-degree flexion and wrist at 0-degree pronation/supination while sitting upright, as shown in Figure 1.

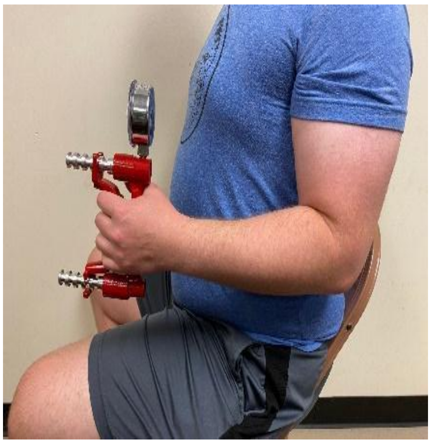

Figure 1: Demonstration of the standard *AMA Guides* method for determining grip strength using a hand dynamometer.

The participant then exerts maximum effort for up to a few seconds and the maximum kg-equivalent force reading on the dynamometer is recorded. Figure 2 shows a typical dynamometer reading.

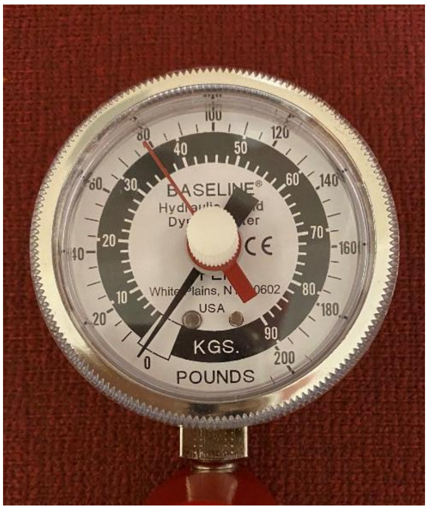

Figure 2: An example of a gauge reading when the dynamometer is used to measure grip strength. The black hand of the dynamometer shows the force applied during testing, and the red hand remains in the position corresponding to the maximum force exerted. When no force is applied, as in the image shown, the black hand gives the offset from zero that must be subtracted (approximately 79 lbs for the maximum and 3 lbs for the offset in the image shown).

The offset from zero varied throughout the experiment presumably due to changes in temperature, so it was important to subtract this offset from the dynamometer reading for proper calibration.

Part II: At-Home Method

The at-home protocol used in this study utilizes a water bottle to evaluate grip strength as an alternative to using a hand dynamometer. A participant squeezes the bottle with maximum grip exertion to expel water horizontally from a known height above the (level) ground, and the horizontal distance the water travels before striking the ground is measured.

This method uses inexpensive, easily accessible materials including:

- A 700 mL LifeWater Sport Top water bottle, as shown in Figure 3

- A folding table with four standard pencils taped to the table, as shown in Figure 4
- Chairs on opposite sides of the table to allow participants to test both their right and left hands (Figure 4 illustrates an example of left-hand testing.)

Figure 3: An example of the 700 ml LifeWater Sport Top water bottle used during testing by all participants for consistency.

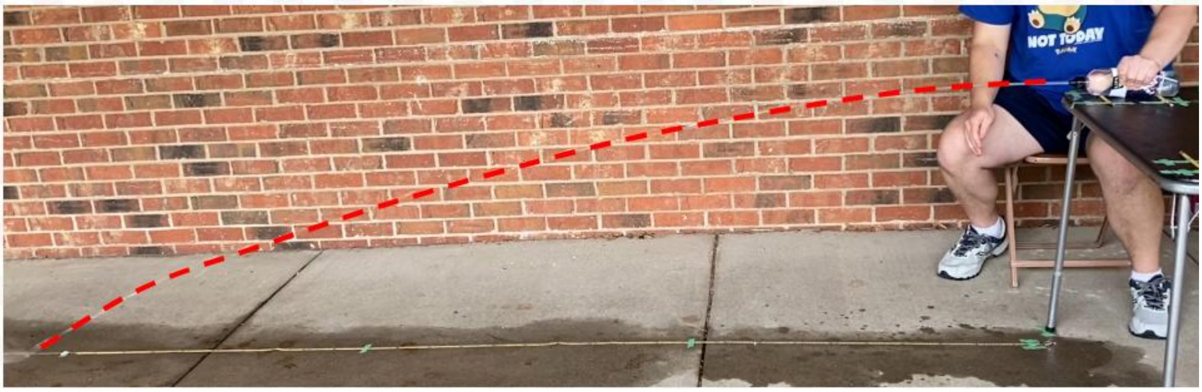

Figure 4: A demonstration of the at-home method which uses a water bottle to determine grip strength.

The water bottles were replaced after they began showing signs of wear to ensure reproducibility. Note that the protocol outlined herein can easily be applied to a table of any height, but the water bottle must be the same brand and type specified to produce results consistent with this study.

As shown in Figure 4, to set up the experiment, the two pencils are taped 8.0 and 23.0 cm from the edge of the table creating supports for the water bottle to rest upon. The water bottle bulges in the middle when it is squeezed during testing, but the pencils help keep the bottle level while this distortion occurs so that the water exits horizontally, as intended. Measuring tapes are taped to the ground on each side of the table (i.e., for testing of both right and left hands) with the zero-reading on the measuring tape being directly below the nozzle of the water bottle which is aligned with the front edge of the table. The bottle is oriented so that the water's trajectory will be in the same vertical plane as the tape measure to allow the horizontal distance travelled by the water to be measured. Although the red, dashed curve shown in Figure 4 was added to draw attention to the water's trajectory, the water can be seen between the dashes under careful inspection.

To perform a trial of the at-home method, the participant holds the filled, uncapped, bottle upright, then places their middle finger over the line in the label where the white meets the blue color (see Figure 3). The participant then uses a finger from their opposite hand to cover the opening of the bottle to prevent the water from spilling. The participant then places the bottle on the pencils with the tip flush with the edge of the table. Upon instruction, the participant removes their finger from covering the tip of the bottle and immediately exerts maximum grip strength to expel the water horizontally. This effort is sustained for up to a few seconds. The water is measured at the farthest point where it initially strikes the ground (i.e., neglecting splashing). This distance is used to calculate the exit velocity of the water using fundamental formulas of physics [20], as follows:

$d = v_o t$

$h = \frac{1}{2} g t^2$

Therefore,

$v_o = \frac{d}{t} = d\sqrt{\frac{g}{2h}}$

Where:

$d =$ horizontal distance water traveled

$v_o =$ (horizontal) exit velocity of water

$t =$ time water is in the air before first striking the ground

$h =$ height of bottle tip above ground ($0.740m$ in this experiment)

$g = 9.80\frac{m}{s^2}$ (acceleration due to gravity)

Although someone at home will likely use a table with a different height, they would just have to measure the height of the water bottle tip above the ground and use that in the exit velocity equation above. Note that the exit velocity of the water found here will be used to determine the grip-strength force exerted on the bottle, as explained in the following section.

RESULTS

The primary goal of this paper is to determine a way to measure grip strength by establishing a clear relationship between the water's exit velocity and the individual's grip strength based on the above procedures. Participants were instructed to exert maximum grip strength in each case, so it was assumed that the average dynamometer reading for a given individual's specific hand could be equated to the kg-equivalent grip strength applied to the water bottle by that hand.

The graph shown in Figure 5 illustrates the relationship between the exit velocity of the water and the kg-equivalent grip strength.

Although there is much variation in the data points, there does seem to be an underlying linear relationship with an r^2 value of 0.595. Such variation is often seen when working with human subjects in this manner, which is why it is important to gather a significant amount of data, as was done here with measurements performed on 213 uninjured hands.

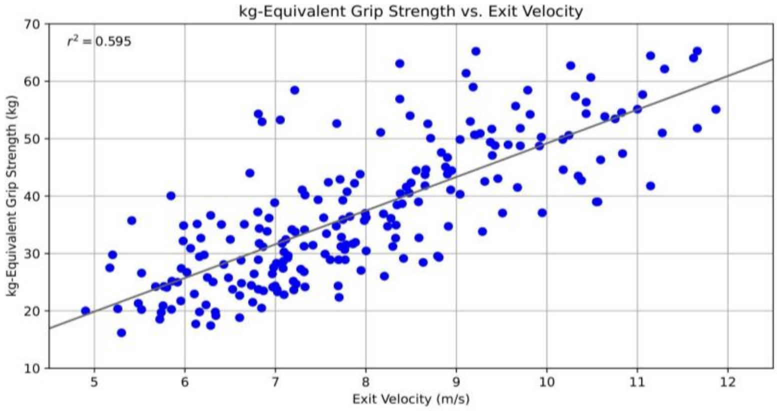

Figure 5: A graph showing the relation between kg-equivalent grip strength as measured with the dynamometer and exit velocity of the water from the bottle in parts I and II of the procedure, respectively. The trendline and corresponding r^2 value are shown.

Table 1 shows all the data groups (male/female, age, and hand dominance) as well as the average kg-equivalent grip strength, the average water distance in meters, and the number of data points in each group.

Average kg-Equivalent Grip Strength and Water Distance					
Gender	**Hand**	**Age**	**Strength (kg)**	**Distance (m)**	**# of Data Points**
Female	Major	11-20	29.9	2.67	27
Female	Minor	11-20	26.3	2.57	26
Female	Major	21-30	30.9	2.79	8
Female	Minor	21-30	28.2	2.80	7
Female	Major	31-40	36.8	3.27	3
Female	Minor	31-40	32.8	3.30	3
Female	Major	41-50	28.8	2.88	6
Female	Minor	41-50	27.4	2.72	6
Female	Major	51-60	29.4	2.80	6
Female	Minor	51-60	27.2	2.71	6
Female	Major	61-70	32.2	2.80	2
Female	Minor	61-70	27.3	2.64	3
Female	Major	71-80	N/a	N/a	0
Female	Minor	71-80	N/a	N/a	0
Male	Major	11-20	44.2	3.31	15
Male	Minor	11-20	39.0	3.15	16
Male	Major	21-30	50.4	3.33	11
Male	Minor	21-30	48.1	3.33	11
Male	Major	31-40	47.9	3.62	6
Male	Minor	31-40	43.5	3.53	5
Male	Major	41-50	53.1	3.66	6
Male	Minor	41-50	50.8	3.53	6
Male	Major	51-60	45.1	3.63	9
Male	Minor	51-60	43.3	3.50	9
Male	Major	61-70	45.6	3.56	6
Male	Minor	61-70	42.1	3,57	6
Male	Major	71-80	33.0	3.02	2
Male	Minor	71-80	34.2	2.84	2

Table 1: All grip-strength data sorted by gender, hand dominance, and age.

To verify that the data met the consistency requirements outlined in the *AMA Guides*, standard deviations were calculated separately for males and females, major and minor hands, and both protocols. These standard deviations are shown in Table 2.

Standard Deviations for Grip-Strength Measurements and Water Distance				
Gender: Hand: Number of Data Points:	**Male Major Hand 55**	**Male Minor Hand 55**	**Female Major Hand 52**	**Female Minor Hand 51**
Part I Protocol: Dynamometer Reading (kg)	6.34%	5.79%	7.12%	6.45%
Part II Protocol: Water Distance (m)	6.52%	5.53%	6.95%	5.87%

Table 2: A table showing standard deviations in measurements broken down into all relevant categories: male and female, major and minor hands, and both protocols (dynamometer and water bottle).

As seen in Table 2, all the standard deviations are within the 10% threshold mandated by the *AMA Guides* for results to be considered valid [14].

As a check, the data gathered in this project was organized by age in order to compare it with previous studies, as shown in Figure 6a and 6b.

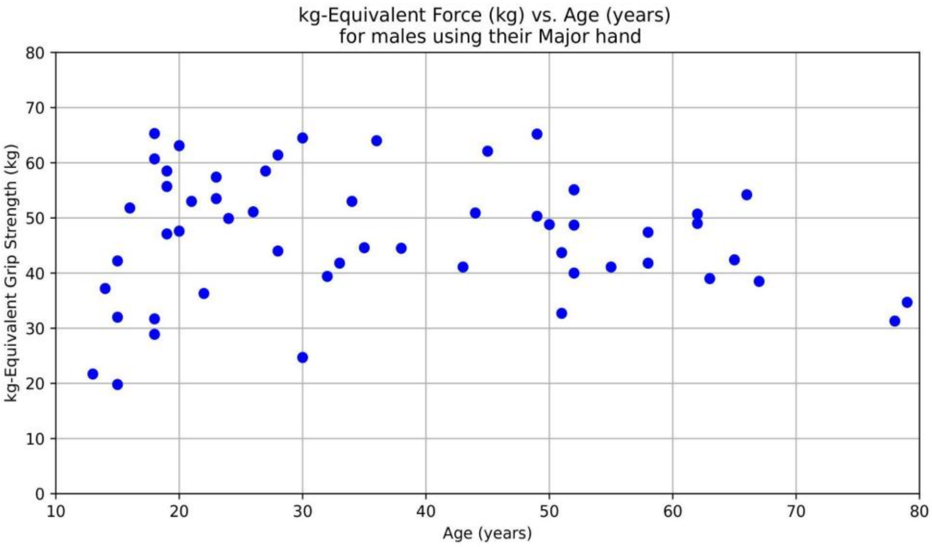

Figure 6a: kg-Equivalent grip strength for the major hands of males by age.

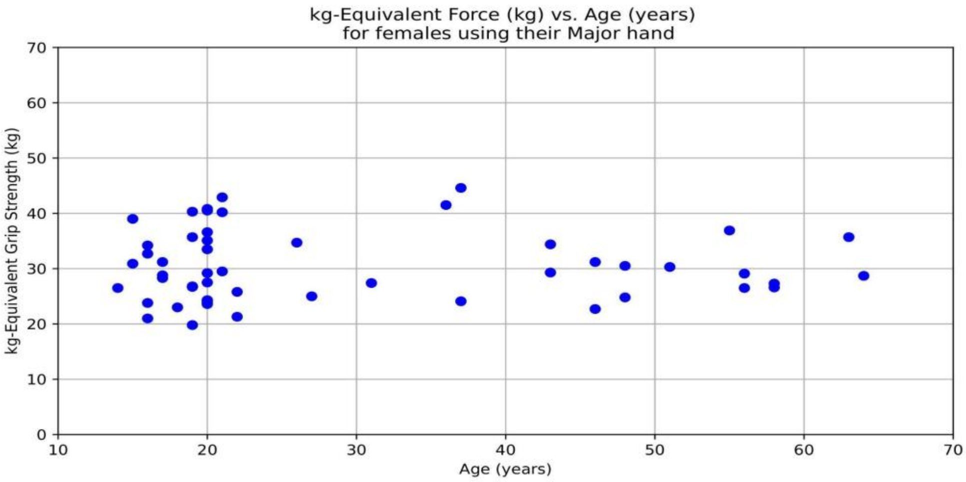

Figure 6b: kg-Equivalent grip strength for the major hands of females by age.

DISCUSSION OF POTENTIAL ERRORS

Medical evaluations inherently present sources of error which may be minimized by following an appropriate protocol. With the at-home protocol presented herein, there are a few common problems that may lead to inaccurate measurements of the horizontal distance the water travels, as follows:

- The maximum distance to where the water first hits the ground (neglecting splashing) can be difficult to measure. This was addressed by having multiple research team members observe each trial whenever possible.
- The water bottle would occasionally lift or tilt upwards. As mentioned above, having the bottle rest on pencils allowed for the middle of the bottle to bulge without significant tilting, but a small amount of tilting was still possible. To address this, researchers reminded participants to keep the bottle horizontal, and sometimes even held the tip of the water bottle to prevent it from rising (for overzealous participants). Any trials where the bottle visibly tilted upwards were redone.
- Participants would sometimes press down on the water bottle with their testing arm. Since this study is only intended to test grip strength, not other forces exerted on the bottle, participants were asked to redo trials where this was observed.

CONCLUSIONS

The at-home method has been proven to produce very similar results to the *AMA Guides*-approved method. The authors contend that the at-home method could serve as a preliminary test for individuals to determine whether an impairment exists to see if a visit to a doctor is necessary.

In practice, a doctor could determine the relevant minimum grip strength for an individual patient that would correspond to an uninjured hand. Using the kg-equivalent force versus exit velocity graph presented above, the doctor could relate this minimum grip strength to the corresponding exit velocity. Passing this information along to the patient, the patient, using the height of the water nozzle above the floor can determine the horizontal distance to where the water would hit the floor for this minimum grip strength.

The patient could put a piece of tape on the floor at this location and try multiple times to see if they can reach this distance using the at-home method presented here. If the patient can consistently hit or exceed this distance with the water from the bottle, the patient is likely uninjured and would not qualify for worker's compensation. If the patient consistently falls short of this distance, it may be worth a visit to the doctor's office for a thorough grip-strength test using a dynamometer.

If the water falls short of reaching the tape, the patient could relay the measured distance that the water travelled to the doctor to get a rough idea of the level of impairment.

REFERENCES

1. Lam O, Broderick B, Toor S (2018) How far Americans live from the closest hospital differs by community type. Pew Research Center; Pew Research Center.
2. Pew Research Center (2023) Inflation, health costs, partisan cooperation among the nation's top problems. Pew Research Center - U.S. Politics & Policy.
3. Buvik A, Bergmo TS, Bugge E, et al (2019) Cost-effectiveness of telemedicine in remote orthopedic consultations: Randomized controlled trial. Journal of Medicine and Internet Research 21(2): e11330.
4. Marin A (2020) Telemedicine takes center stage in the COVID-19 pandemic.
5. Wootton R (1996) Telemedicine: A cautious welcome. BMJ 313(7069): 1375-1377.
6. Hailey D, Crowe B (2003) A profile of success and failure in telehealth: Evidence and opinion from the successes and failures in telehealth conferences. Journal of Telemedicine and Telecare 9(2_suppl): 22-24.

7. Hjelm NM (2005) Benefits and drawbacks of telemedicine. Journal of Telemedicine and Telecare 11(2): 60-70.
8. Haukipuro K, Ohinmaa A, Winblad I, et al (2000) The feasibility of telemedicine for orthopaedic outpatient clinics: A randomized controlled trial. Journal of Telemedicine and Telecare 6(4): 193-198.
9. Galea MD (2019) Telemedicine in rehabilitation. Physical Medicine and Rehabilitation Clinics 30(2): 473-483.
10. Jacobs K, Blanchard B, Baker N (2012) Telehealth and ergonomics: A pilot study. Technology and Health Care 20(5): 445-458.
11. Mair F, Ferguson J (2008) More patients with minor injuries could be seen by telemedicine. Journal of Telemedicine and Telecare 14(3): 132-134.
12. Cottrell MA, O'Leary SP, Swete-Kelly P, et al (2018) Agreement between telehealth and in-person assessment of patients with chronic musculoskeletal conditions presenting to an advanced-practice physiotherapy screening clinic. Musculoskeletal Science and Practice 38: 99-105.
13. Weinstein RS, Lopez AM, Joseph BA, et al (2014) Telemedicine, telehealth, and mobile health applications that work: Opportunities and barriers. American Journal of Medicine 127(3): 183-187
14. Hailey D, Roine R, Ohinmaa A (2002) Systematic review of evidence for the benefits of telemedicine. Journal of Telemedicine and Telecare 8(1_suppl): 1-7
15. American Medical Association (2022) *AMA Guides* Sixth 2023: Current medicine for permanent impairment ratings. American Medical Association.
16. National Safety Council (2024) Workers’ compensation costs.
17. Alchemy G, Alchemy S, Bolon B, et al (2021) Occupational telemedicine for pinch strength testing: A pilot study of methods for at-home measurement. Research Article 4(S9): 28-38.
18. Griebel Z, Bolon B, Artz J, et al (2022) A pilot study for at-home measurement of grip strength via telemedicine. Journal of Clinical Cases & Reports 2023(S11): 133-142.
19. Global Industrial (2024) Baseline® LiTE® hydraulic hand dynamometer, 200 lb capacity, red. www.globalindustrial.com.
20. Sears FW, Zemansky MW, Young HD (1987) University physics 7th edn. Addison-Wesley Series in Physics, Reading, Pennsylvania.