# Hand Grip Strength as a Predictor for Success in Weaning from Ventilation

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**ABSTRACT** **Background:** Timely extubation is important integral part of the treatment of intensive care patients.

**Objective:** To evaluate hand grip strength using a Jamar Hydraulic Hand Dynamometer as a predictor of success or failure in weaning from ventilation.

**Methods:** This prospective study included 104 patients (62 males, 42 females) who were ventilated in the general intensive care unit (ICU), and who were alert and cooperating. They undertook a hand grip strength test using the Jamar dynamometer, within hours of extubation. Patients needing resuscitation within 72 hours were defined as failure.

**Results:** Success rate in weaning from ventilation was 85.6%, and 89 patients successfully weaned from ventilation. Those who were successfully weaned had stronger hand grip than those who failed. Males had a mean kg-strength 31.3 ± 11.5 vs. 23.6 ± 10.3 ($P$ = 0.033), and in females mean kg-strength 23.14 ± 16.39 vs. 11.67 ± 10.33 ($P$ = 0.031). A threshold value (22.5 kg-strength) was found to predict success for weaning from ventilation in the male group, with a sensitivity of 70.0% and a specificity of 62.5%. In the female group, the duration of the ventilation alone was statistically significant ($P$ = 0.049).

**Conclusions:** There was a connection between hand strength and success in weaning from ventilation. A threshold value can help the medical staff to decide on extubation. Hand grip strength can predict successful weaning from ventilation and does not require high skills, time, a large staff, or high financial cost, and it does not endanger the patient.

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**KEY WORDS:** dynamometer, hand grip strength, threshold value, ventilator weaning failure, ventilator weaning success

Critical-care patients can acquire intensive care unit (ICU)-acquired weakness (ICUAW) and acquired muscle weakness that affects limbs and respiratory muscles [1,2]. The condition is accompanied by a delay and/or a decisive failure in weaning from the ventilator, mainly as a result of respiratory muscle dysfunction and/or poor cough [3,4]. According to the Medical Research Council (MRC) scale, a bedside test requiring a skilled physiotherapist is considered to be the accepted standard for assessing peripheral muscle strength tested in previous studies [3,5,6]. Testing dominant hand strength using a handheld dynamometer to assess muscle strength is an easy, fast, and non-invasive operation, which has shown reliability in its results similar to the scale score of MRC [7,8].

In an effort to reduce morbidity and mortality, performing extubation at the correct time is extremely important as an integral part of the treatment of ICU patients [4]. It is well known that beyond the prolonged respiratory damage of ventilation, premature extubation can also cause damage and significantly reduce the patient's chance of being successfully weaned from the respirator [8]. The aim of the present study was to evaluate hand grip strength as measured by the Jamar Hydraulic Hand Dynamometer (Jamar Hydraulic Hand Dynamometer, Sammons Preston Rolyan, Bolingbrook, IL, USA) as a predictor of the success and failure of weaning from ventilation.

## PATIENTS AND METHODS

This double-blind prospective study was conducted in the respiratory intensive care unit (ICU) at Galilee Medical Center, Nahariya, Israel, from early November 2017 until late November 2018, in accordance with the medical center's ethics committee. All patients signed informed consent documents.

Adult inpatients in the respiratory ICU (≥ 18 years) of both sexes, who were receiving artificial ventilation and were candidates for extubation according to the accepted criteria in the ward, were considered as potential study participants. Only patients who were awake and quiet and who scored between 1 and 1+ on the Richmond Agitation Sedation Scale (RASS) [9] were evaluated for study participation by the Attention Screening Exam (ASE), a visual standard test for ICU patients [10]. Only patients who scored 8 or higher participated in the study. It is important to note that all ventilated patients at Galilee Medical Center are hospitalized exclusively in the respiratory ICU. Exclusion criteria included patients with a disease known to cause general weakness (e.g., myasthenia gravis, Guillain-Barre syndrome, other muscle diseases, or neurological problems), non-communicating patients (due to medication, confusion, dementia, Alzheimer's disease, or language), blind patients, patients with paralysis or an orthopedic problem in the dominant

hand, or patients who had received neuromuscular blocker medication in the previous few hours.

After having received an explanation of the course and goal of the study, and after having signed an informed consent document, each participant was asked to perform a hand grip test three times in the dominant hand using a *Jamar* dynamometer. The patient was allowed to rest for 30 seconds between each test [11,12]. The highest value of all three grips was considered the hand grip force for that particular participant. The test was performed in a sitting position with the elbow at an angle as close to 90 degrees as possible, according to the guidelines of the American Society of Hand Therapists [12]. The device was copiously cleaned and disinfected after each participant. Furthermore, the handgrip tests were performed by the department's physiotherapist without the presence of the departmental staff; thus, the medical staff's treatment of the patients and extubation efforts were not affected by knowledge of the results of the test. The value of hand grip strength is expressed as an absolute value in kilograms [10], and ICUAW is calculated in kilograms (11 kg for men and 7 kg for women). In addition, information was collected on demographics (e.g., age, sex, body mass index, telephone number), reason for ventilation, background illnesses, surgeries and medications in the current hospitalization, and respiratory conditions in addition to vital signs and blood tests. The date and time of the test and the time of extubation were also recorded.

Each participant was followed for 3 days after weaning from ventilation. A participant requiring re-intubation was defined as a failure, and the cause of return to ventilation was recorded. Those who did not require re-intubation over the next 3 days were defined as successful, and for them the follow-up lasted one month.

### STATISTICAL ANALYSIS

Qualitative data were described using frequencies and percentages. Quantitative data were described using averages and standard deviations, medians, and range.

A comparison was made of the age, sex, and handgrip power of patients whose weaning from ventilation was successful vs. those whose weaning failed. Qualitative data were compared using chi-square test or Fisher's exact test, according to applicability. Quantitative data were compared using the independent sample *t*-test or the Wilcoxon rank sum test (Mann-Whitney), also according to applicability.

An attempt was made to define a cut-off value for the force produced in the hand grip strength test according to sex, mainly based on the receiver operating characteristic (ROC) curve. A logistical regression adjustment was performed to examine the relationship between the force produced in the hand grip test and successful extubation. We focused on fitting a multivariate regression model that also included patient characteristics. Statistical significance was considered as $P < 0.05$. Statistical analyses were performed using IBM Statistical Package for the Social Sciences statistics software, version 25 (SPSS, IBM Corp, Armonk, NY, USA).

## RESULTS

During the study period, 315 patients were admitted to the respiratory intensive care unit at Galilee Medical Center, of whom 104 (33.0%) were found to fit the inclusion criteria of the study (62 males and 42 females). No statistically significant difference in age was found between males and females, mean age (59.4 ± 19.8 years vs. 64.1 ± 15.9, respectively; $P = 0.18$), or mean number of respiration days before weaning, (3.6 ± 3.2 vs. 3.3 ± 3.4, respectively; $P = 0.872$). A statistically significant difference was found between the percentage of males vs. females who smoked (76.7% vs.45%, $P = 0.001$). Another significant difference that stood out between the two groups was background diseases, with a larger percentage of females presenting with background diseases vs. males, $P = 0.024$ [Table 1].

The success rate in weaning from ventilation was 85.6% (89 patients). No difference was found between males and females in the weaning success rates [85.5% (53 males) vs. 85.7% (36 females), $P = 0.97$]. The average dominant hand grip strength for all participants was 24.83 kg-strength, although males had stronger compressive strength than females (28.3 vs. 15.5 kg-strength, respectively; $P < 0.001$). There were no differences in background characteristics between those females who succeeded vs. those who failed in the weaning process, nor between the males who weaned from ventilation successfully vs. those who failed. However, a statistically significant difference was found between mean age and mean hand strength in the group of females who failed weaning (76.8 ± 13.8, 11.67 ± 10.33 kg-strength) vs. the group of females who successfully weaned (62.0 ± 15.5, 23.14 ± 16.39 kg-strength), $P = 0.019$, $P = 0.031$, respectively. In contrast, in the male group, patients who were successfully weaned from respiration had a stronger hand grip (mean 31.3 ± 11.5 ± kg-strength) compared to failed patients (23.6 ± 10.3 kg-strength), $P = 0.033$, with no statistically significant difference in age between the two groups, (57.9 ± 20.3 vs. 68.1 ± 14.1, $P = 0.195$ [Figure 1].

Based on the hand grip data collected in the study, an ROC curve was constructed to find a threshold value that would help predict success in weaning from ventilation. The results shown are for males only because no similar analysis could be offered for females as only six failed weaning. The value, with the combination of maximum sensitivity and specificity values, was defined as the best threshold value for predicting success. The threshold value for predicting success in weaning from ventilation among males was 22.5 kg-strength with a maximum sensitivity of 70.7% and a maximum specificity of 62.5% [Figure 2].

In a multivariate analysis, some parameters were introduced that could have affected the chances of success in weaning from

**Table 1.** Demographic data of the study participants

| Characteristics | Male N (%) | Female N (%) | Total N (%) | *P-value* (2-sided) |
|---|---|---|---|---|
| Participants (%) | 62 (64.5) | 42 (35.5) | 104 (100) | |
| Mean age (years) ± standard deviation | 59.39 ± 19.79 | 64.14 ± 15.95 | 61.31 ± 18.5 | 0.180** |
| **Co-morbidities** | | | | |
| **Reason for ventilation, n (%)** | | | | |
| Respiratory (%) | 25 (40.3) | 22 (52.4) | 47 (45.2) | 0.225** |
| Cardiac (%) | 22 (35.5) | 17 (40.5%) | 39 (37.5) | 0.606** |
| Metabolic (%) | 34 (54.8) | 28 (66.7) | 62 (59.6) | 0.228** |
| Malignancy (%) | 5 (8.1) | 5 (11.9) | 10 (9.6) | 0.52*** |
| Other (%)<br>No co-morbidities (%) | 29 (58)<br>14 (22.6) | 26 (63)<br>2 (4.8) | 55 (60.4)<br>16 (15.4) | 0.162*<br>0.024* |
| Hospitalized for surgery (%) | 23 (37.1) | 8 (19.5) | 31 (30.1) | 0.079* |
| Mean number of respiration days ± standard deviation | 3.6 | 3.3 ± 3.4 | 3.5 ± 3.3 | 0.872** |
| **Nutritional status** | | | | |
| Obese (%) | 20 (32.3) | 20 (47.6) | 40 (38.5) | |
| Normal (%) | 36 (58.1) | 20 (47.6) | 56 (53.8) | 0.108** |
| Underweight (%) | 6 (9.7) | 2 (4.8) | 8 (7.7) | |
| Smoker (%) | 46 (76.7) | 18 (45) | 64 (64.0) | 0.001* |
| Steroids in current hospitalization (%) | 28 (51.9) | 17 (45.9) | 45 (49.5) | 0.580* |

*chi-square test
**Mann-Whitney test
***Fisher's exact test

ventilation: age, sex, duration of respiration, steroid treatment, and hand-grip strength (above and below the threshold of 22.5 kg-strength). According to backward elimination it was found that age, sex, steroid treatment, and duration of respiration did not have a statistically significant effect. Another trend that was observed: patients with strong handgrip (threshold value 22.5 kg-strength or higher) tended to wean successfully from the respirator compared to patients with weaker handgrip (less than the threshold value). This result was not statistically significant ($P = 0.151$), but the odds ratio (OR) was relatively high (3.6) [Table 2]. In a multivariate logistic analysis for the male group, we did not find that variable hand grip variability was related to success, given the patient's age and respiration duration ($P = 0.115$, $P = 0.425$, respectively). Among females, respiration duration alone was found to be statistically significant ($P = 0.049$).

**Table 2.** Multivariate analysis, men's group

| | *P* value | Odds ratio |
|---|---|---|
| Age | 0.894 | 0.996 |
| Duration of respiration | 0.504 | 1.185 |
| Steroid treatment | 0.038 | 0.089 |
| Threshold value | 0.151 | 3.646 |

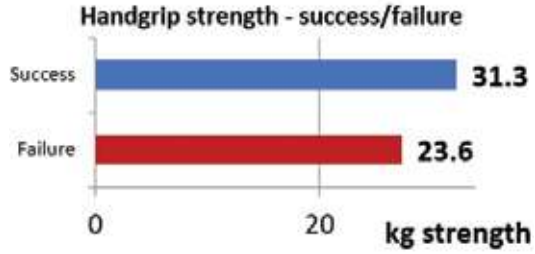
## DISCUSSION

The results of our prospective study mainly refer to the male group due to few weaning failures in the female group, which did not allow statistically significant conclusions to be drawn. We focused mainly on interpretation of the results obtained in the men's group, with reference to the women's group in order to show general trends without conclusions.

Average hand-grip strength in the male group was, as expected, higher than that of the females, due to greater muscle mass in men vs. women [12]. Despite the difference in grip strength between the two groups, no difference was found in the percentage of success in weaning from ventilation, a result consistent with other studies that examined ventilated males and females [7]. This result is expected, since in healthy people the gross strength in males is greater than in females, and yet this finding had no effect on survival after difficult events or on life expectancy in women [13].

**Figure 1.** Handgrip strength and weaning success/failure

**Men's group**




**Women's group**

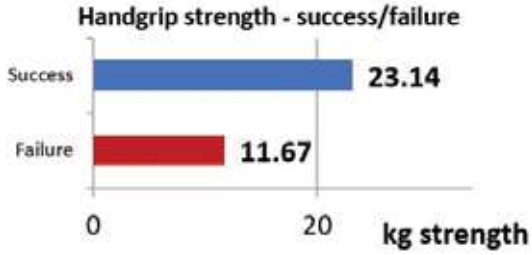
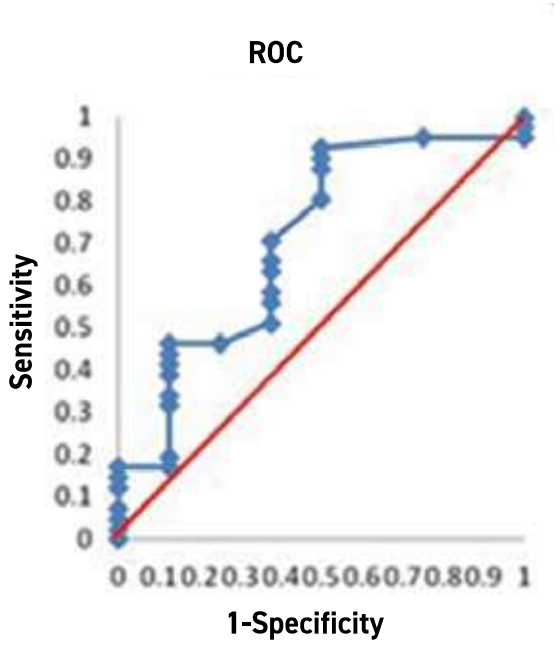



**Figure 2.** ROC curve from which threshold values were determined with maximum the sum of sensitivity and specificity (70.7% and 62.5%, respectively) for predicting success in weaning from ventilation. The values stand at 22.5 kg

ROC = receiver operating characteristic




The expected difference in gross strength between the males and females led us to divide the participants into two groups for examination of the relationship between hand-grip strength and success in weaning from ventilation according to group. Indeed, the average hand-grip strength of men who successfully weaned was 31.3 kg-strength vs. 23.6 kg-strength for those who failed, with statistical significance. A similar trend with no statistical significance was observed in the women's group.

A review of the literature revealed several studies similar to ours that demonstrated significant difference in hand strength between the successfully weaned group of patients vs. those who failed, and with the successfully weaned groups achieving higher values [14-16]. Another study showed a significant association between low hand grip values and mortality in ventilated patients [8].

These results may be explained by ICUAW, which indicates general muscle weakness and decreased neurological function [14] in respiratory patients in an ICU. Several studies have shown a significant association between ICUAW and prolonged respiration, failure in weaning and mortality rates [8,17]. The diagnosis is made by special tests and scales, which we did not utilize in the present study.

In our study we relied on statistical calculations to find the optimal threshold value, which was defined as the hand-grip value with the highest sensitivity and specificity for predicting success or failure in weaning from ventilation. This value was defined as 22.5 (70.7% sensitivity and 62.5% specificity). Next, we tried to find a clear relationship between success in weaning from ventilation and grip strength that is above the threshold value. Unfortunately, no statistically significant association was found, but a trend can be seen with OR at about 4, indicating that patients with a grip strength above 22.5 were 4 times more successful than those who achieved a lower value. Lack of statistically significant association was likely due to the small number of participants.

The threshold value obtained in our study differs from threshold values in a similar study that identified ICUAP and mortality rates by hand-grip strength. This difference may be due to differences in age, background illnesses, duration of respiration, and causes of respiration, but it is also possible that this difference is due to differences in the ethnic origin of the participants. The study by Messi-Stroop and Chabad [17] found a difference in the average hand-grip strength between different ethnic populations in both males and females. It is therefore important to estimate a threshold value for the ethnic populations in a specific country, and even to find a unique threshold value for each hospital according to the characteristics of its patient population.

In our study, the failure rate in weaning from ventilation was 14.5%, an acceptable value according to the literature, which shows a re-intubation rate ranging from 2% to 25% [19]. Our study did not include all ventilated patients in the ICU, rather only those who met our inclusion criteria and achieved a score of 8 or higher on the ASE test, which shows a high level of alertness and cooperation. Thus, it is possible that our overall failure rate did not reflect the true value of all respirated patients. How-

ever, the results we obtained showing a difference in hand-grip strength of this selected group indicate that hand-grip strength can indeed be used as a predictive factor.

Our study illustrated secondary findings, such as the relationship between steroid treatment and the chance of success in weaning. Those treated with steroids were more likely to fail weaning than those who were not because steroids cause muscle catabolism [20], probably including the respiratory muscles, and thus are a risk factor for ICUAW development [17]. This finding illustrates the importance of careful consideration in providing steroid therapy. In studies examining the effect of steroid administration prior to extubation to reduce the risk of stridor and the need for reintubation, the results were not unequivocal [21].

Other factors such as age and duration of respiration were not found to significantly affect the chances of successful weaning from ventilation. This result is inconsistent with the study by Kulkarni and Agarwal [22], which showed that young patients weaned more successfully from ventilation than older patients, possibly due to less severe disease or fewer background illnesses. Also, several studies have shown that the duration of respiration does affect the chances of weaning success due to the development of ICUAP [22,23]. Perhaps our results can be attributed to fact that ours was a small research group, and our patients' mean respiration duration was 2.8 days. The duration of respiration factor had minimal effect.

## LIMITATIONS

The small number of participants (especially female) is the main limitation of this study, and thus no conclusions could be drawn in the women's group, nor could we achieve a statistically significant threshold value with high sensitivity and specificity. However, despite the small number of participants we were able to demonstrate a significant relationship in the men's group. Another limitation, also due to the small number of participants, was our inability to divide the patients into groups according to the cause for respiration (e.g., surgery, internal disease). This division may have highlighted the significance of the hand-grip strength test in one group vs. another.

During the study, we tried to perform the hand-grip test as late as possible after the cessation of sedative therapy and muscle blockers, and as close as possible to the time of extubation. Despite our best efforts, evacuation of drugs is individual to each patient, and depends on basic health and underlying conditions. Thus, it is possible that the levels of these drugs in the blood affected the participants differently.

Most of hand-grip strength tests and patient follow-up were performed by one researcher to maintain uniformity in the manner in which the test was performed. Moreover, the other researchers participated in supervised practice of the hand-grip test to achieve as much uniformity as possible. Utilizing the optimal sitting and elbow position at a 90-degree angle was not always possible due to participants' health limitations.

We utilized only the handgrip test, without comparing it to other tried-and-true tests such as diaphragmatic ultrasound or tidal volume-respiratory rate ratio [24,25].

## CONCLUSIONS

The hand-grip strength test is low-cost, easy to perform, requires only one person without special training, and does not endanger the patient in any way. Our results showed a connection between hand strength and successful weaning from ventilation. A threshold value can be reached that will help the medical staff decide whether to extubate. However, this threshold value may differ from one ethnic group to another, and this factor should be taken into consideration. Further studies with a larger number of participants, are needed to reach clearer conclusions.

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Capsule

## Retroviral origins of antiviral proteins

Sequences of retroviral origins are abundant in the human genome, but their functional significance remains poorly understood. **Frank** and co-authors identified a pool of sequences derived from retroviral envelopes (which normally facilitate viral entry into cells) that are expressed during human fetal development, viral infection, and immune stimulation. The authors hypothesized that some of these sequences encode proteins with antiviral activity by binding to and competing for cell surface receptors targeted by infectious viruses. Genetic manipulation in cell culture showed that one such protein, SUPYN, was capable of restricting infection by type D retroviruses circulating in several mammals.

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Capsule

## Measuring menstruation after vaccines

Menstrual changes, particularly longer cycles and heavier bleeding, have been reported in association with various vaccines, including those for COVID-19. These observations have led to widespread misinformation that resulted in COVID-19 vaccine hesitancy among young women. Various studies have since found that although menstruation can be affected by COVID-19 vaccination, these changes are transient and resolve within a few months. In a perspective, **Male** discussed studies looking at how COVID-19 vaccination and infection affect menstruation and the possible underlying mechanisms. These effects are not routinely monitored in vaccine trials, and this is a missed opportunity that could reveal feedback between the immune system and the female reproductive system.

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Eitan Israeli

Capsule

## Sustenance for skin-resident $T_H17$ cells

The T helper 17 ($T_H17$) cell subset provides host protection from extracellular pathogens but also contributes to autoimmune diseases. Interleukin-23 (IL-23) promotes cutaneous $T_H17$ responses, but the source of the IL-23 that supports skin-resident memory $T_H17$ cells has been unclear. **Whitley** and *co*-authors characterized the effects of blocking IL-23–mediated signaling in mice on $T_H17$ function in defending against skin infection by *Candida albicans* and in promoting inflammatory dermatitis. Dermal myeloid cells were identified as the critical source of IL-23 needed to sustain skin-resident memory $T_H17$ cells. These findings provide a deeper understanding of how blocking antibodies targeting either IL-23 or its receptor can hold aberrant cutaneous $T_H17$ responses in check, providing a durable therapeutic benefit to patients with $T_H17$-mediated inflammatory skin diseases such as psoriasis.

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