

Is there a stronger correlation between hand span and grip strength, or height and grip strength?

Hypothesis

There will be a stronger relationship between hand span and grip strength than height and grip strength.

Research:

The three different types of muscles in the body; skeletal, cardiac and smooth have a range of functions. Skeletal muscle is striated and under voluntary control with the main function being movement.

Muscles are attached to bones via tendons, with the point of attachment being either the origin or insertion. Muscle contraction starts with an electrical impulse in response to a stimulus with the action potential traveling along the muscle fibres. Muscles do not work in isolation and coordinate movement is a result of one muscle contracting (agonist), whilst the other muscle relaxes (antagonist). Muscle contraction can be explained through the sliding filament theory as it is due to actin filaments 'sliding' relative to myosin filaments.

The handgrip strength test will look at isometric contraction of muscles of the arm and hand using a Vernier Hand Dynamometer. Muscle fatigue will come into play as after a period of time squeezing the dynamometer there is likely to be a sense of weakness and discomfort, which will lead the participant not squeezing the dynamometer.

Dependent variable

- Hand span in cm (± 0.1 cm)
- Height in cm (± 0.5 cm)

Dependent variable

- Handgrip strength in newton (± 0.1 N)

Safety

Issues within the investigation, which need to be addressed to ensure the safety of participants, would involve a PAR-Q questionnaire being completed to ensure all are fit and healthy and able to participate in the experiment.

Equipment

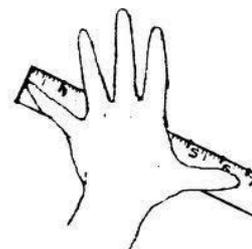
- Computer
- Vernier Data Logger
- Vernier Hand Dynamometer
- Ruler
- Height measuring stand
- 3 Test conductors for measuring hand span, height and hand grip strength
- 3 recorders to record hand span, height and hand grip strength

Method

1. All participants 'names' from two teachers' grade 8 PE classes (aged 14-15 years) are keyed into a list at the start of the lesson on the mini web tool site (<http://www.miniwebtool.com>) with 40 names being selected randomly for the investigation.
2. The 40 selected participants are invited by the teacher to the classroom off the sports hall to receive further instructions from the test conductor. Participants are allocated to groups and allocated a number based on when their name was selected:
 - a. Group 1: Number one to ten
 - b. Group 2: Number eleven to twenty
 - c. Group 3: Number twenty one to thirty
 - d. Group 4: Number thirty to forty
3. All participants are asked to sign a consent form and PAR-Q. All are invited to attend the investigation on either day 1, day 2, day 3 or day 4 wearing sports kit (trainers, socks, shorts, t-shirt) based on their allocated group.
 - a. Group 1: Monday @ 10am
 - b. Group 2: Tuesday @ 10am
 - c. Group 3: Wednesday @ 10am
 - d. Group 4: Thursday @ 10am
4. The test conductor informs participants that the task will consist of measuring their hand span, height and grip strength. Each handgrip test will consist of three trials. Participants informed that the results will be kept confidential and they have a right to withdraw themselves or their results from the experiment at any time.
5. Equipment collated and experiment set up to measure:
 - Hand span in cm (± 0.1 cm)
 - Height in meters (cm) (± 0.5 cm)
 - Handgrip strength in newton (± 0.1 N)
6. Recorder reminded to record all qualitative and quantitative data in a clear and appropriate manner for each task
7. On arrival group 1 participants are reminded by the test conductor of the following tasks and taken through each task step by step by 3 different test conductors (see step 9, 10 & 11).
 - Hand span measurement
 - Height measurement
 - Hand grip test – 3 trials
8. Participants taken to room A to record their hand span and height by an external recorder (same conductor for each task) completing each task in the number they were allocated on the day they were selected (e.g.1 to 10)

9. Hand Span Measurement

- The distance to be measured is from the tip of the thumb to the tip of the little finger on the outstretched hand.
- The hand is placed palm down on a flat surface. The fingers are outstretched as far as possible.
- The linear distance (in centimeters) between the outside of the thumb to the outside of the little finger is measured.



10. Height Measurement

- Participant to remove shoes, hair ornaments or hairstyles that add to their height.
- Participant to stand on platform with back to wall.
- Participant to stand up straight and look straight ahead, touching the stand with the back of head and buttocks.
- Recorder to stand at eye level with the top of head and move the ruler so it is touching the top of the head; this is the height to be recorded.



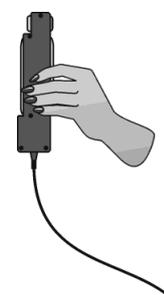
11. Handgrip Dynamometer Procedure

- Measure and compare grip strength to the nearest 0.1 N (e.g. 205.7 N) of participant's dominant hand for 3 trials for each participant for a total of 10 seconds. See below for detailed instructions from the 'Human Physiology with Vernier' Lab book by Diana Gordon and Steve I. Gordon, M.D.
 - Demonstration & verbal cues for all participants with each participant being allowed one practice attempt, and being able to view their own results and maximum force attained in every trial.
12. Participants called up in number order and upon completing the first handgrip strength test, complete trial 2 and trial 3. The same procedure is repeated until all participants have completed all 3 trials.
13. Participants thanked and debriefed with and explanation of the aim of the investigation and hypothesis (see appendix 1b for debrief notes).
14. Above process (step 7 to 13) repeated for participant from group 2, 3 and 4 on the allocated days.

HAND GRIP DYNAMOMETER PROCEDURE

Hand Grip Strength

- Connect the Hand Dynamometer to the Vernier computer interface. Open the file "16a Compare Grip Strength" from the *Human Physiology with Vernier* folder.
- Zero the readings for the Hand Dynamometer.
 - Hold the Hand Dynamometer along the sides, in an upright position. Do not put any force on the pads of the Hand Dynamometer.
 - Click the Zero button, .



Have the subject sit with his or her back straight and feet flat on the floor. The Hand Dynamometer should be held in the dominant hand. The elbow should be at a 90° angle, with the arm unsupported.

3. Subject can keep eyes open and look at maximum force recorded on the screen.
4. Click **▶ Collect** to begin data collection. After collecting 2 s of baseline data, instruct the subject to grip the sensor with full strength for the next 8 s with the command GO. Data will be collected for 2 s (10 seconds in total).
5. Record the maximum force for trial 1, and repeat the process (step 2 to 5) for trials 2 and 3.



Results

Table 1.1: Data table showing participant: gender, height (cm), hand span (cm), grip strength per trial (N) and average grip strength (N)

Participant	Gender	Height (±0.5 cm)	Hand Span (±0.1 cm)	Grip Strength (±0.1 N)			
				Trial 1	Trial 2	Trial 3	Average
1	Male	154.5	19.3	188.7	202.6	189.1	193.5
2	Male	170.0	18.2	162.4	155.2	145.1	154.2
3	Male	151.0	18.1	164.3	160.7	137.8	154.3
4	Male	151.0	19.8	181.3	147.5	145.6	158.1
5	Male	142.5	17.6	156.3	135.5	84.2	125.3
6	Male	165.0	20.4	164.8	213.2	158.2	178.7
7	Male	158.0	13.0	151.2	138.4	121.6	137.1
8	Male	159.5	18.5	248.3	237.2	223.4	236.3
9	Male	174.0	24.1	263.7	214.6	230.3	236.2
10	Male	166.5	16.5	171.1	130.7	151.8	151.2
11	Female	157.0	20.7	197.5	167.6	187.6	184.2
12	Female	154.5	19.9	112.0	115.3	94.7	107.3
13	Female	174.5	21.0	184.8	187.3	167.3	179.8
14	Female	158.5	21.2	159.4	136.7	112.7	136.3
15	Female	162.5	17.5	204.2	185.8	183.1	191.0
16	Male	163.0	21.5	167.2	173.7	164.5	168.5
17	Male	142.0	19.1	154.5	151.9	123.8	143.4
18	Male	154.0	20.6	127.4	112.6	111.7	117.2
19	Male	140.0	17.0	133.7	93.6	117.0	114.8

Participant	Gender	Height (± 0.5 cm)	Hand Span (± 0.1 cm)	Grip Strength (± 0.1 N)			
				Trial 1	Trial 2	Trial 3	Average
20	Male	166.0	22.3	269.7	240.3	265.9	258.6
21	Female	166.0	19.8	118.5	127.4	99.7	115.2
22	Female	159.0	20.6	193.6	182.2	161.3	179.0
23	Female	165.0	21.0	146.9	153.5	153.9	151.4
24	Female	153.0	21.2	201.9	217.5	176.3	198.6
25	Female	164.0	20.7	162.1	158.9	149.4	156.8
26	Male	168.0	19.6	228.3	217.2	198.8	214.8
27	Male	162.5	20.3	184.9	164.5	211.1	186.8
28	Male	183.0	22.5	280.6	243.1	240.5	254.7
29	Male	177.5	21.5	230.4	221.7	213.1	221.7
30	Female	154.5	19.5	140.7	139.6	137.0	139.1
31	Female	161.0	19.0	152.2	111.8	120.0	128.0
32	Female	166.0	20.0	190.9	174.4	176.7	180.7
33	Female	158.5	18.5	129.1	189.1	126.2	148.1
34	Female	164.5	20.0	197.7	187.5	167.6	184.3
35	Male	157.5	19.0	161.0	181.1	175.8	172.6
36	Male	178.0	22.0	153.8	145.5	144.2	147.8
37	Male	189.5	23.5	365.4	350.0	319.6	345.0
38	Male	172.0	24.5	291.8	302.0	304.2	299.3
39	Male	178.0	24.0	399.6	364.8	323.0	362.5

Table 1.1: (Continued)Key: → Anomalies**Qualitative Data:****Participant 1:** Sports: Football, Skiing, Triathlons (Running, Cycling, Swimming)**Participant 2:** Sports: Basketball, Badminton, Skiing**Participant 3:** Sports: Tennis, Badminton, Hockey, Golf**Participant 4:** Sports: Rock Climbing**Participant 5:** Sports: Football, Basketball**Participant 6:** Sports: Rugby, Swimming, Basketball**Participant 7:** Sports: Football, Rugby**Participant 8:** Sports: Tennis, Basketball**Participant 9:** Sports: Basketball**Participant 10:** Sports: Football**Participant 16:** Sports: Tennis**Participant 17:** Sports: Tennis

Participant 18: Sports: Cycling
Participant 20: Sports: Basketball
Participant 24: Sports: Swimming
Participant 26: Sports: Rock Climbing
Participant 27: Sports: Basketball
Participant 28: Sports: Cricket, Golf
Participant 29: Sports: Squash, Football
Participant 30: Sports: Tennis
Participant 31: Sports: Tennis, Football
Participant 32: Sports: Fencing
Participant 33: Sports: Tennis
Participant 34: Sports: Rugby
Participant 35: Playing tennis immediately prior to testing
Participant 36: Playing tennis immediately prior to testing
Participant 37: Playing tennis immediately prior to testing
Participant 38: Playing tennis immediately prior to testing
Participant 39: Playing tennis immediately prior to testing

Sample Calculations:

Average: $\frac{\text{Added Total From Three Trials}}{\text{Number of Trials}}$

$$\text{Participant 1} = \frac{188.7+202.6+189.1}{3} = \frac{580.4}{3} \approx 193.5$$

$$\text{Participant 2} = \frac{162.4+155.2+145.1}{3} = \frac{462.7}{3} = 154.2$$

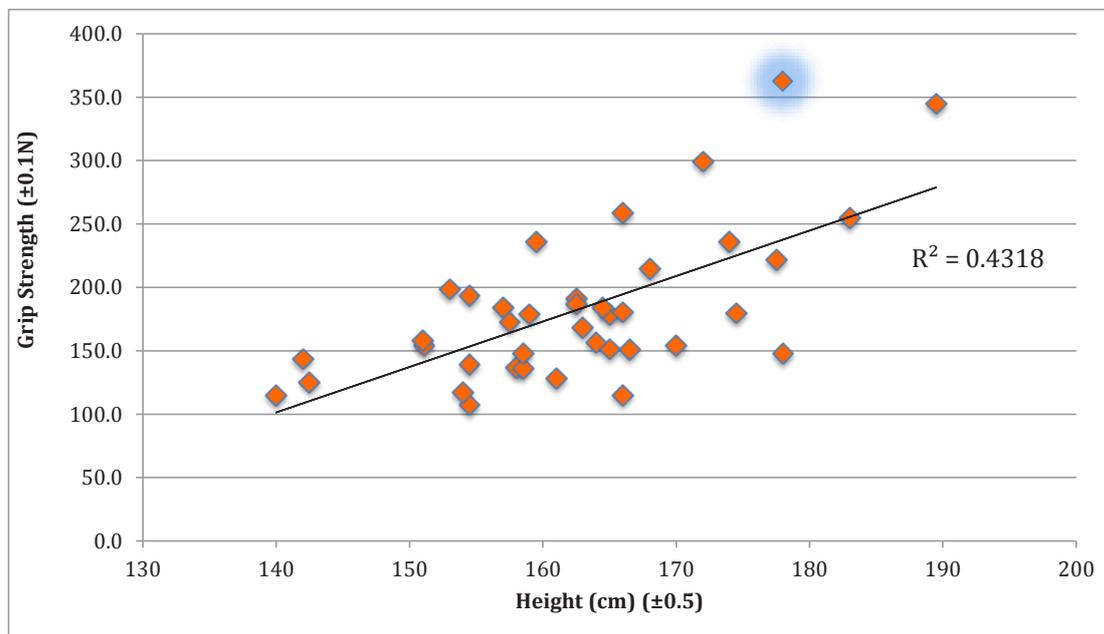
$$\text{Participant 3} = \frac{164.3+160.7+137.8}{3} = \frac{462.8}{3} \approx 154.3$$

Coefficient of Determination: (Calculated using Excel)

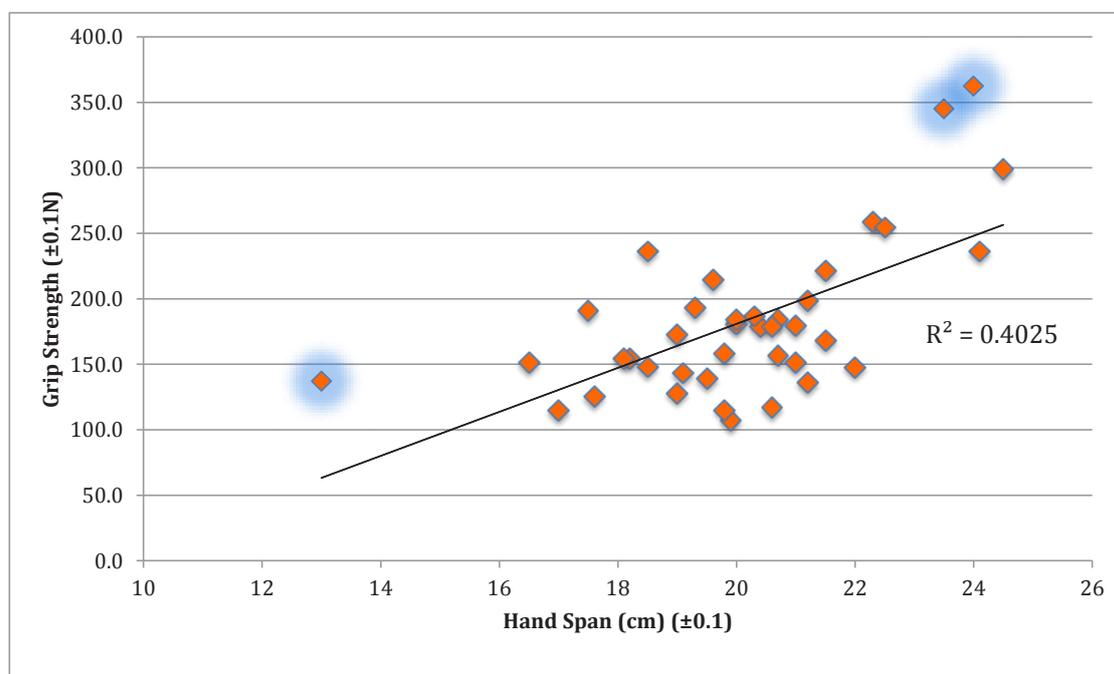
R² = 0.432 (3.s.f) - The regression coefficient of 0.432 (3.s.f) shows there is a weak positive correlation between grip strength and height. The positive correlation means as height increases, average grip strength also increases.

Line of Best Fit: The regression line or line of best fit indicates the relationship between the two variables. The relationship of the two variables is statistically calculated and expressed through the coefficient of determination (R²) that ranges from 0 to 1. The closer the value is to 0 the weaker the correlation is, therefore the closer the value is to 1, the stronger the correlation.

Graph 1.1: Scatter plot demonstrating the correlation between height (± 0.5 cm) and the average grip strength (± 0.1 N).



Graph 1.2: Scatter plot demonstrating the correlation between hand span (± 0.1 cm) and the average grip strength (± 0.1 N).



Coefficient of Determination: (Calculated using Excel)

$R^2 = 0.403$ (3.s.f) - The regression coefficient of 0.403 (3.s.f) shows there is a weak positive correlation between grip strength and hand span. The positive coefficient of determination demonstrates as hand span increases, average grip strength also increases.

Line of Best Fit: The regression line or line of best fit indicates the relationship between the two variables. The relationship of the two variables is statistically calculated and expressed through the coefficient of determination (R^2) that ranges from 0 to 1. The closer the value is to 0 the weaker the correlation is, therefore the closer the value is to 1, the stronger the correlation

Conclusion:

After conducting testing for this experiment, the hypothesis that the relationship between hand span and grip strength would be stronger than the one between height and grip strength has been rejected. My findings illustrate the coefficient of determination for the correlation between height and grip strength as 0.432 whereas the coefficient of determination for the correlation between hand span and grip strength is 0.403. Although the coefficient of determination value is slightly higher for height, both the values show weak correlation and the closeness of the values could show ambiguity in the results.

Examining the data in both Graph 1.1 (showing the relationship between height and grip strength) and Graph 1.2 (showing the relationship between hand span and grip strength), the correlations appear to be weak for both height and hand span. Concluding from my findings, there does not appear to be a correlation between either hand span and grip strength or height and grip strength. Both graphs have weak positive correlations and a similar spread of data which explains the similar coefficient of determination. The correlation between height and grip strength is slightly higher. However both the graphs are including anomalies which could affect the reading of the coefficient of determination.

The results are slightly affected by **some anomalies**. However, these anomalies would need to be included in the data and graphs because since the focus is on correlation, the anomalies usually only affect either of the conditions but cannot be disregarded if they are to be included for the other condition. Different people have growth spurts at different times, meaning a thirteen year old could be as tall as an eighteen year old but the eighteen year old in most cases will have a more developed body and more strength (*BBC*)¹ This is seen in the data collected for participants thirty-six (36) and thirty-nine (39). Both the participants are of the same height of 176.0 centimeters, but the difference in average grip strength is of 214.7 N (participant 36 averaging a 147.8 N grip strength and participant 39 averaging a 365.2 N grip strength). Height and hand span are both measurements of the body, but for this type of experiment perhaps the age of the participant would be more relevant as teenagers tend to get stronger as they mature physically and go through puberty, however as previously stated height is not an indication of age and two people of similar heights could vary extremely in strength simply due to an important age difference.

¹ "BBC - Science & Nature - Human Body and Mind - Teenagers." *BBC - Homepage*. N.p., n.d. Web. 5 June 2013. <<http://www.bbc.co.uk/science/humanbody/body/articles/lifecycle/teenagers/growth.shtml>>.

When comparing my findings to scientific journals produced recently there is both supporting and rejecting material. The first study I looked at, a study from [Guru Nanak Dev University](#)² described the correlation between grip strength and height as being 'significantly positive' whereas the correlation between grip strength and hand span (hand length) is described as being 'positive'. This study therefore supports my results in which I found the correlation between height and grip strength, although it was a weak positive correlation, was still stronger than the correlation between hand span and grip strength by a small margin.

However, another study I examined, written by [Mohamed Sherif Sirajudeen](#)³ rejected my findings, supporting the original hypothesis. This study states the coefficient of determination between hand span and grip strength is 0.64 whereas the coefficient of determination between height and grip strength is 0.52 (rounded figure). The difference between the two figures is quite significant which shows ambiguity in the whole situation. Various testers have gotten various results for the same kind of experiment and the correlation between grip strength and anthropometric traits is never extremely strong, it most ranges in the weak/medium sections. Therefore no statistically correct conclusion can be made about the study except the fact that my findings rejected by hypothesis.

The results found correspond with what you would expect in general human populations. Not every one of similar heights/hand spans will be of similar strengths which is what was demonstrated by the results. It is expected the correlation between the two factors and grip strength would be quite low for this reason. Grip strength can also be worked on, sports such as tennis or softball for example could improve your grip strength and the firmness of your grip at the moment of contact is an important aspect of both these sports. Weightlifting exercises could also play a part in increasing grip strength and grip stability is important when lifting weight in proper form.

Hand strength and function is extremely important for every day activities for humans. Pushing doors open, tying your shoe lace, cutting food all require hand force and strength to be performed, and these are only a very limited selection of all activities which require hand strength. Function of the hand is also very important for the same reasons. Doctors and physical therapists are very interested in grip strength because it is easily measureable and is a good indicator of the force of all the muscles in the human body (*Zoomhealth*)⁴. Orthopedic surgeons are also interested in grip strength to evaluate the extent of an injury and the estimated recovery period (*Vernier*)⁵. Overall muscle force in the body is increasingly important when striving for a healthy and long life. The assumption is made that if you have a strong hand grip, implying a strong upper body, your lower body muscles will also be strong - a positive sign of health and prosperity. Handgrip changes with time (age) and health condition (*Vernier*). Grip strength can be used by doctors and physical

² "Grip Strength Comparison." *Vernier*. N.p., n.d. Web. 5 June 2013. <http://www2.vernier.com/sample_labs/HP-A-16-COMP-grip_strength_comparison.pdf>.

³ Sherif Sirajudeen, Mohamed. "Correlation between Grip Strength and Physical Factors in Men - International Journal of Health and Rehabilitation Sciences (IJHRS) - ScopeMed.org - Online Journal Management System." *ScopeMed.org - Online Journal Management System*. N.p., n.d. Web. 5 June 2013. <<http://www.scopemed.org/?mno=28516>>.

⁴ Carr, Louise, and Featured Columnist. "Why Hand Grip Is Important to Your Health." *ZoomHealth-Increase Your Health IQ*. N.p., n.d. Web. 5 June 2013. <<http://www.zoomhealth.net/WhyHandGripIsImportanttoYourHealth.html>>.

⁵ "Grip Strength Comparison." *Vernier*. N.p., n.d. Web. 5 June 2013. <http://www2.vernier.com/sample_labs/HP-A-16-COMP-grip_strength_comparison.pdf>.

therapists to diagnose neuromuscular problems such as tendonitis in the arm (*Vernier*). Athletes are interested in grip strength as they can use it to see how their overall muscle force in the body has changed, and athletes participating in sports such as tennis, golf, softball will always be keen to know their grip strength, as it is an important aspect of their respective games.

To gather my results, many **ethical guidelines** were addressed and followed. Participants were briefed and debriefed on the experiment and the grip strength process and their personal information has remained confidential. Participants reserved the right to remove themselves from the testing at any time and were not put through any strenuous situations, which could damage health. The results have remained confidential by suppression of name, and were returned to the participant if they desired to see them. Participants were put through no activity which could damage mental and/or physical health.

A key strength of the investigation was that knowledge of results (KoR) was shared with participants after each trial with regard to the maximum force they attained. The aim here was to try and increase the motivation of participants and encourage them to give 100%. Seeing their results adds an effect of competition to the task as participants would try harder to beat their friends if they know the scores they got. To further increase the competitive aspect in the experiment the top score to date could be shared with all participants, however, it is important that the name of the participant is not revealed.

In conclusion, the prediction that there will be a stronger relationship between hand span and grip strength than height and grip strength was rejected.

Weakness 1: Fatigue – between trials
Fatigue between trials – The majority of participants scored their highest grip strength on their first trial and less as the trials progressed.
Significance of Error: Moderate
One third of subjects had the lowest grip strength for the third trial. Although the skill is quite simple, it does require a lot of energy in a very short moment therefore participants do need a rest period.
Suggested Improvement
To eliminate this error, instead of one participant performing all three of his trials consecutively. It would be more suitable to give participants a rest period between trials so they have time to recover. To do so, each participant should proceed with their first trial and then go to the back of the line and wait for their 2 nd attempt ensuring the order stays the same.

Weakness 2: Fatigue - during 10 second test
Most high results were achieved within the first few seconds of the 10 second task. Therefore there is no need for the ten-second testing period as results in most cases decreased in the final half of the testing period. The extension of the testing time also increased fatigue levels for no apparent reason and appear to have resulted in lower results in further trials.
Significance of Error: High
Significant - As observed throughout the testing phase of the experiment, many participants reached their highest grip force within the first few seconds of the eight second testing period. The error becomes very significant because it affects further reading due to unnecessary fatigue.
Suggested Improvement

To eliminate or reduce this weakness, testing time period should be reduced from ten (10) seconds to five (5) seconds. The shorter testing period also means participants will need less time to fully recover before their next trial.

Weakness 3: Hand/arm position

Positioning of Participant Hand/Arm - If participants do not all do the experiment in the same way they can be put to a significant advantage or disadvantage. The experiment was designed to be conducted with the arm at a 90-degree angle not resting on your thigh. If participants rest their arm on their thigh they may get more stability and can push down on their thigh to have a stronger grip.

Significance of Error: High

Some participants may have benefited from resting their arm on their thigh when being tested. Different experimenters might be slightly more lenient, adding subjectivity to the results.

Suggested Improvement

To control this weakness and remove the possibility of subjective results, the experimenter should remain the same and ensure all the participants proceed in an identical manner e.g. elbow on table.

Weakness 4: Procedure – test conductors

If different experimenters allow the participants to hold the dynamometer differently or if they give them more resting time than other experimenters their results may be affected. The procedure was established before the experiment took place therefore this weakness should not have been a factor however it can not be presumed that all experimenters followed the guidelines to the same degree.

Significance of Error: Moderate

Participants may not all have held the dynamometer the same way and some may have been resting their arm on another body part. Different hand positions on the dynamometer allow for a tighter and more comfortable grip, therefore affecting some of the results.

Suggested Improvement

The elimination of this error, having a single test conductor for all participants would be more accurate and reliable. A single test conductor would eliminate the subjectivity aspect as all participants, without any exceptions, would have gone through the exact same procedure.

Weakness 5: Motivational Levels

Motivational levels are extremely hard to control. If some participants are much more motivated than others they will push themselves harder and will try to fight through the fatigue harder than participants who did not wish to participate in the experiment in the first place.

Significance of Error: Low

Some participants may have been keener than others to participate in the task, a fact that could be significant as we did not ask for volunteers.

Suggested Improvement

To eliminate this weakness, only participants who volunteer for the experiment should be chosen as they could have more motivation than participants who were 'forced' to participate. The introduction of a prize for the participant with the highest grip strength value in a group may also help eliminate this weakness.

Weakness 6: Gender Ratio

Having both genders involved in the testing does affect the results because although males and females of the same age can be the same height, the male will generally be stronger.

Significance of Error: High

Mixing genders could have affected results as males are generally stronger than females, however, females generally have growth spurts earlier than males.

Suggested Improvement

To eliminate this weakness, selecting participants from a single gender would be more accurate. A male/female can both be 180cm tall but the male in most cases would be stronger. However this is only a presumption and would not be accurate 100% of the time. But, limiting the experiment to a single gender does ensure more accuracy in the results and could have altered my data.

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