Title Page

Article Title: Assessment of Isometric Muscle Exertion in Short-term Considering Task-rest Schedule

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Abstract

31 Numerous workers experience occupational diseases, especially musculoskeletal disorders, due to various
32 physical, psychological, and individual factors. Among known risk factors for musculoskeletal disorders, work-
33 rest patterns, and muscle fatigue are to be named. Assessment of muscle fatigue plays an important role, leading
34 to a proper design for a work-rest program. This study was aimed to investigate isometric muscle strength in
35 Iranian workers during repetitive activities based on gender and rest time. It has been attempted to present a
36 model for isometric muscle strength. In a laboratory experiment, 31 students comprised of 19 males and 12
37 females participated, and muscle strength was recorded by a dynamometer. Minitab software results analysis
38 proved that females' upper body muscles showed a higher level of resistance to fatigue rather than males.
39 Furthermore, tests' results for each individual were more in line with cubic regression so that four models with a
40 high R-Sq index (at least 94.4%) and high R-Sq (adj) index (at least 77.8%) were presented to predict isometric
41 muscle strength in short-run. Finally, it has been suggested to use male workers for repetitive activities with a
42 high workload and enough rest time and use female workers for repetitive activities with low workload and
43 high frequency.

44 Keywords: Ergonomics, Fatigue, Gender, Repetitive Task, Muscle Recovery, Work-Rest Time.

45

46 1. Introduction

47 In European countries, about 20 million workers experience occupational diseases annually, and most of the
48 occupational diseases (about 40%) fall into the category of work-related musculoskeletal disorders (WMSDs)
49 [1-3].

50 Work-related musculoskeletal disorders (WMSDs) can be caused by various physical, psychological, and
51 individual factors. Physical risk factors can include some cases like manual handling (e.g., lifting [3] and
52 pushing/pulling [2]), non-neutral postures (e.g., bending and twisting), and repetitive movements [1]. Static and
53 intermittent static muscle activity, duty cycle, work-rest patterns, and muscle fatigue are among the known risk
54 factors for musculoskeletal disorders [4-6].

55 Muscle fatigue is one of the leading causes of musculoskeletal disorders in the industry, especially for physical
56 work and manual material handling [6], so that lumbar muscle fatigue is a potential risk factor for increasing
57 low back pain [7]. In general, physical fatigue can be defined as ‘any reduction in the maximal capacity to

58 generate force or power output' [8]. Physical fatigue effects might lead to decreased productivity and quality in
59 production systems [9]. Physical fatigue is one of the significant consequences of shift schedule [10], physical
60 exertion [11], physical demands associated with shiftwork [12], long working hours [13], increased work
61 intensity, and prolonged standing among workers population [14, 15]. Fatigue is a challenging ergonomic issue
62 that endangers safety because it reduces productivity and increases injuries rate, so it must be carefully managed
63 with its reasons [16, 17].

64 Muscle fatigue assessment not only for a work-rest time appropriate design but for reducing workers'
65 musculoskeletal injuries and preventing physical fatigue in physical activities is helpful [18, 19]. On the other
66 hand, muscle strength recovery is influenced by rest time length, so rest times should be adjusted to allow
67 muscle recovery occurrence. Generally, time is a significant issue for ergonomics in production system
68 interventions. These interventions use tools like work-rest patterns and daily duration of exposures in workers'
69 health and contribution in production [20].

70 This study was aimed to investigate isometric muscle strength while performing repetitive activities based on
71 gender, rest time, muscle recovery, and fatigue in Iranian workers. It has also been attempted to present a model
72 for isometric muscle strength in the short run. Before going any further, there is a brief review of previous
73 studies of isometric muscle strength, work-rest schedule, muscle recovery, and fatigue.

74 Although it was stated that anthropometric measurements [21] are not good predictors of isometric muscle
75 strength [22], but Mital and Ayoub [23] showed that by considering them, the model explains a higher
76 percentage of the response variation. Kroemer and Marras [24] stated that usually the maximum capacity of a
77 person's muscular strength in tests could not be measured. Individuals apply force with a safety margin below
78 the capacity level, while in the technical term, it is called the maximum voluntary contraction (MVC) that is
79 used as a gold standard for measuring fatigue [8].

80 [25] studied the impact of added rest breaks on the productivity and well-being of 30 workers in the meat-
81 processing plant and found that workers, in general, might not as readily accept fragmentation of break time
82 into short and frequent breaks and prefer long, infrequent breaks. While [26] do not offer long and infrequent
83 breaks for data entry and cognitive tasks. Also, McLean et al. [27] examined the benefits of scheduled rest

breaks (microbreaks) at computer terminals. They concluded that microbreaks had no detrimental effect on worker productivity and had positive effects on reducing discomfort in all areas studied.

Lee [28] calculated the Minimum Acceptable Handling Time Interval (MAHTI) for four-hour lifting and lowering activities using a physiological approach and revealed that with increasing load weight, MAHTI increases significantly nonlinearly. On the other hand, this time for lifting activity is significantly greater than the same lowering activity. Balci and Aghazadeh [26] examined the effect of rest time on performance. They found that the impact of the work-rest schedule was significant on performance, muscular load level, and perceived discomfort. In this way, Adamo et al. [29] stated that intermittent periods of complete rest reduce muscle fatigue, and ergonomic interventions such as increased scheduled breaks or job rotation have been suggested to reduce upper limb muscle fatigue in repetitive low-load activities [30].

Shin and Kim [18] examined the relationship between cumulative fatigue of trunk muscles and change in recovery time and by analyzing fatigue level with analysis of variance (ANOVA), showed that in 5 min recovery time, 90% of the subjects showed a recovery of at least two trunk muscles, while in 4 min recovery time, 70% of subjects experienced such conditions. Also, Jin [31] declared that obtaining knowledge about any abnormality of the recovery phase can help develop an appropriate work-rest schedule.

Mathiassen and Winkel [32] considered three ergonomic interventions (Reduced work pace, increased break allowance, and shortened working days) in light assembly work. They concluded that shortened working days were more effective in limiting acute fatigue than the other two interventions. Nussbaum and Iridiastadi examined the effect of contraction level, duty cycle, and cycle time on muscular fatigue and endurance during intermittent static activity. They concluded that contraction level and duty cycle significantly affect muscular endurance and fatigue, but cycle time is only significant for electromyogram (EMG) spectral measures [33, 34].

[35] presented a four-parameter model for estimating fatigue during an isometric contraction that demonstrated the potential for predicting muscle fatigue in response to a wide range of stimulation patterns. After presenting a new simple dynamic muscle fatigue model, considering the external load, workload history, and individual differences [6], using this model during a single-arm pushing experiment, showed that females' resistance to muscular fatigue was more than males' in the pushing task [19]. Also, [36] showed that females' shoulder fatigue resistance was higher than males' at lower intensity levels.

Based on the literature review, there is a research gap about studying the work-rest schedule and its effects on muscle recovery among Iranian workers, so we tried to investigate this topic using experimental work.

2. Methods

2.1. Methodology

This study aims to obtain results applicable in domestic industries for Iranian workers and production systems, including repetitive tasks (like assembly & Manual Material Handling (MMH)). This study, including two parts of experimental work and result analysis, has been cross-sectional plus laboratory work, in which volunteers' anthropometric data recorded through interviews. The dependent variable is isometric muscle strength, while the independent variables of the study are age, gender, height (cm), weight (kg), and rest time (second).

2.2. Sample Size & Participants

The study population for this research was bachelor students from the Industrial Engineering Faculty of Iran University of Science and Technology (IUST) located in Tehran. The bachelor student population of the Industrial Engineering Faculty during 2020 January was 329, with both male and female students [21]. We used the Cochran formula to calculate the theoretical sample size. With a confidence level of 95% and a sampling error of 0.1, the theoretical sample size was 74.35. But restrictions on the spread of the Coronavirus did not let us realize it. So we had to decrease the confidence level to 87%, and the theoretical sample size was 29.09. Regarding the theoretical sample size, a sample size of 31 in this study would be sufficiently precise to estimate with an 87% confidence interval.

In this study, using random sampling, 31 volunteer students of the Industrial Engineering Faculty participated. This group is comprised of 19 males and 12 females, and the experiments were conducted in the Advanced Ergonomics Lab in the School of Architecture and Urban Development at IUST. The conditions and purposes of the experiments were fully explained to the students.

2.3. Procedure

A dynamometer with a gram-force (gr.f) unit has been used in the current study. This dynamometer can display the isometric force of muscles at any moment [3] (as shown in Figure 1). Besides, this device can be adjusted to show the maximum isometric force applied in a short interval [3], and this capability was used in this study.

137 INSERT Figure 1 HERE

138 In laboratory work, participants stand completely on a dynamometer base, gripping two-handed chainsaws so
139 that handles are held in the palm of their hands in a way that fingers are tightened around the handle. Grasping
140 the handle as the power grip, in which the elbow angle is 90 degrees, and the wrist has no flexion (Figure 2). In
141 this case, to have a 90 degree in elbow, the height of the handle was adjusted. Then volunteer pulls the handles
142 upwards without any excessive force that causes fatigue or overexertion. The following mentioned steps by
143 volunteer, at last, the maximum isometric force recorded by the dynamometer, has been written down.

144 Considering four different rest times (one minute, 30 seconds, 15 seconds, and 10 seconds) [37] with a
145 stopwatch, this test was repeated four other times (according to Figure 2), and the results were recorded. At the
146 end of the experiment, every volunteer's height, weight, and age had been written down. Paired T-test,
147 Anderson Darling test, Univariate linear regression, nonlinear regression, and Pearson correlation coefficients
148 were used to analyze data while obtaining a significant relationship between the independent and dependent
149 variables of the research. It should be noted that some similar cubic curves in terms of coefficients and
150 appearance merged by averaging the points and fitting a new cubic curve. The confidence level of 0.95 was also
151 considered for all methods, and Minitab software (Version 16) has been used to analyze the experiment's data.

152 INSERT Figure 2 HERE

153 3. Results

154 Volunteers' mean height was 171.554 cm, with a standard deviation of 8.951 cm. Volunteers' mean weight was
155 71.378 kg with a standard deviation of 18.027 kg, and volunteers' mean age was 21.355 years with a standard
156 deviation of 1.279 years.

157 In Table 1, the results are presented according to the abbreviations. As shown in Figure 3, an average of each
158 measurement, according to males and females, can be found. In the five measurements, females' average
159 isometric muscle strength was 63%, 60%, 61%, 54%, and 56% lower than the isometric muscle strength of
160 males, respectively. In other words, in every test, the average isometric muscle strength of females is 59% lower
161 than that of males. Also, the normality of the data for both males ($P\text{-Value} = 0.719$) and females ($P\text{-Value} =$
162 0.939) was confirmed by the Anderson Darling test, and no data deletion was required. Finally, a paired t-test

163 showed a significant difference between the muscular isometric strength recorded for males and females (*P*-
164 *Value=0.000*).

165 INSERT Table 1 HERE

166 INSERT Figure 3 HERE

167 In Figure 4, to make each volunteers' isometric muscle strength trend during five tests more comprehensible,
168 diagrams of isometric muscle strength were recorded for 31 individuals, plotted by gender and slope sign of
169 regression line. The accuracy of the fitted linear regression lines is low, and the purpose of the diagrams is to
170 observe the isometric muscle strength general trend, individually. In Figure 4, it should be noted that the
171 numbers represent the volunteer number, and the graphs on the left have a positive slope, while the graphs on
172 the right have a negative slope. According to Figure 4, nine males and nine females have ascending slopes
173 while ten males and only three females have descending slopes in isometric muscle strength linear regression
174 graphs. It means that only 25% of females experienced a downward trend in isometric muscle strength, while
175 75% of females experienced an increase in isometric muscle strength with a low slope. 53% of males
176 experienced a downward trend, while 47% of them experienced an upward trend.

177 INSERT Figure 4 HERE

178 According to Figure 5, linear regression and Pearson correlation coefficient were used to obtain the correlation
179 between the results of the five tests; correspondingly, a significant relationship between the isometric muscle
180 strength of both tests was seen, so that the minimum $R-Sq$ was 79.8% and the maximum was 97.3%. There is
181 no meaningful relationship between the mean measurements for males and females in the i -th test ($R - Sq =$
182 41.3%). Additionally, there was also a significant relationship between mean measurements for females and
183 time ($R - Sq = 79.8\%$), but not for males ($R - Sq = 29.6\%$).

184 INSERT Figure 5 HERE

185 A nonlinear regression (third-degree) was used to determine the isometric muscle strength fluctuations in all
186 five tests. According to Figure 6, a cubic curve was obtained for each group by separating males' and females'
187 data. Also, through fitting a cubic curve for individuals, a high percentage of the response variable variation is
188 explained in all three curves (between 79.2% and 89.9%).

189 INSERT Figure 6 HERE

190 Through fitting a cubic curve for each of the individual's five tests (Table A.1 in Appendix A), it seems that
191 many curves are almost similar in terms of coefficients and appearance. As explained in part (2.3. Procedure),
192 by fitting a new cubic curve, the accuracy of the new fitted cubic curve increased ($R - Sq$ between 94.4% and
193 98.8%). Figure 7 shows the four categories of curves resulting from the above process (Fig. S1 in
194 supplementary data file). The test results of 24 individuals (77% of volunteers) corresponded roughly to one
195 of the four curves above.

196 INSERT Figure 7 HERE

197 4. Discussion

198 In each test, females' average isometric muscle strength was 59% lower than that of males. From first to
199 second, third to fourth, and fourth to the fifth test, males showed isometric muscle strength decreased. This is
200 while females only showed isometric muscle strength loss from the fourth to fifth test, which means isometric
201 muscle strength drop occurred in males more frequently and earlier than females; it means females' upper body
202 muscles resistance to fatigue was more than males. While previous studies have emphasized greater resistance
203 to muscular fatigue in females than males in arm pushing activity [19] and shoulder muscle fatigue at lower
204 intensity levels [36].

205 On the other hand, males did not have proper muscle recovery within one minute. However, after 90 seconds,
206 muscle recovery has occurred, and again, this recovery did not occur in 15 or 10 seconds (Figure 3).
207 Nevertheless, at low applied force level, females showed suitable muscle recovery for one minute, 30 seconds,
208 and 15 seconds and only in 10 seconds, no muscle recovery has taken place (Figure 3). So the effect of rest time
209 length on muscle recovery and the relationship between upper body muscles fatigue and change in recovery
210 time [18] confirmed. In this case study, it can also be concluded that short and frequent rest times are more
211 suitable for females, while longer and infrequent rest breaks are more suitable for males; in contrary to what
212 was suggested in the previous study about long and infrequent breaks for all workers [25].

213 Generally, the isometric muscle strength of the volunteers did not follow the linear or quadratic curves during
214 the five tests. It seems that the cubic curve can demonstrate muscle strength fluctuations in a short time based

on rest duration well. While in Figure 7, a decrease (increase) in isometric muscle strength from a test to the next test shows insufficient (sufficient) rest time for muscle recovery.

According to Figure 5, there was a meaningful correlation between the result of each test and the result of the next one. By decreasing the rest time between the two experiments, the correlation between the successive isometric muscle strength values increased. For example, between the first and second tests with a 1-minute interval, the Pearson correlation coefficient is 0.937; while, between the second and third tests with a 30-second interval, this coefficient is 0.946. Between the third and fourth tests with a 15-second interval, this coefficient is 0.967, and finally, between the fourth and fifth tests with a 10-second interval, the Pearson correlation coefficient is 0.986. There is also a correlation between the mean muscle isometric strength of females and time, while for males, there is not (Figure 5).

In Figure 6, three categories of cubic graphs presented for predicting short-term isometric muscle strength show that muscular isometric strength fluctuations are higher in males than in females, which is sinusoidal also, this is while females' isometric muscle strength trend is upward. On the other hand, due to the greater number of males in the test and their more substantial muscle strength values, the cubic graph for all volunteers looks very much like the males' cubic curve. In Figure 7, since the four presented categories of cubic graphs are grouped according to the apparent similarity of individuals' graphs, both the R-Sq and the R-Sq (adj) have a significant improvement over Figure 6. Increase from (79.2%-89.9%) range to (94.4%-98.8%) for R-Sq, and increase from (16.9%-59.4%) range to (77.8%-95.3%) for R-Sq (adj), admit this improvement; however, only 77% of volunteers follow one of these curves.

5. Conclusion

The results showed a significant relationship between changes in rest-time duration with maximal isometric muscle strength, and rest time can affect muscle recovery or cumulative fatigue. On the other hand, gender is an influential factor in isometric muscle strength, and this strength is meaningfully higher in males than in females. Females' upper body muscles are more resistant to fatigue than males; it means females became tired later and lower than males in this case study. However, on average, females' applied force was 41% of males. Therefore, in this case study, it is recommended to use male workers for repetitive activities (such as MMH and assembly)

241 that require a high amount of force and sufficient resting time, and use female workers for repetitive tasks
242 require low applied force with high rhythm or the frequency with short rest time.

243 Besides, results have shown that performing repetitive activities with applying force is influenced by task
244 frequency and duration of rest time between activities. Therefore, the production/assembly line pace must be
245 adjusted so that enables the worker to rest at an appropriate time and then do the next force exertion; So in a
246 situation where the production line speed is increased for some reason, assistant worker(s) must join in
247 proportion to the increased speed and required rest time.

248 The research contributions are 1- investigating and mathematical modeling of maximal isometric muscle
249 strength among Iranian students in the short term considering rest time, and 2- investigating muscle recovery
250 and muscle fatigue during repetitive tasks among Iranian collegians based on gender. The research limitations
251 can be stated below: 1- The sample size consisted of university students only. 2- The sample size was small to
252 generalize the results to Iranian workers.

253 While using a greater sample size among Iranian workers, research results also can be used to design assembly
254 and packaging lines in domestic industries, design appropriate work-rest schedules, select workers based on
255 gender and work conditions to perform repetitive activities. Additionally, three categories of generalized cubic
256 graphs and four classified cubic graphs can predict isometric muscle strength in the short term for bachelor
257 students.

258 **Acknowledgment**

259 We should appreciate the Advanced Ergonomics Lab members in the School of Architecture and Urban
260 Development at IUST who had special cooperation in the laboratory work data.

261 **Declaration of Conflicting Interests**

262 The authors declare that there is no conflict of interest.

263 **Supplementary data:**

264 Supplementary data is available at:

265 <file:///C:/Users/SHAMILA/AppData/Local/Temp/Supplementary%20Data%20File.pdf>

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Appendix A

361 The equations of cubic fitted curves of isometric muscle strength for 31 volunteers can be found in Table
362 A.1:

363 INSERT Table A.1 HERE

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365 **Biographies**

366 **Ali Chegini** was born in Tehran, Iran in 1996. He received his BS and MS degree from Iran University
367 of Science and Technology (IUST) in 2018 and 2021. He is currently a research assistant at Iran
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370 **Rouzbah Ghousi** received his Ph.D. from Iran University of Science and Technology in 2013 and
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373 include human factors engineering and ergonomics, diagnosis of production and services systems, data
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375 **Hassan Sadeghi Naeini** received his Ph.D. degree in Environmental Planning from the University of
376 Tehran in 2010. He is currently an associate professor at Iran University of Science and Technology
377 (IUST). His expertise is Ergonomic Design, and he has been teaching Ergonomics and human factors
378 engineering for about two decades. Also, most of his publications, whether as books or articles, are
379 focused on the mentioned field. His recent research works are focused on sustainability.

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Figures Captions

- Figure 1. Dynamometer Manufactured by Iranian Danesh Salar
- Figure 2. Experimental Procedure
- Figure 3. Mean isometric muscle strength in five tests by males and females
- Figure 4. Linear regression graphs of isometric muscle strength for each individual by gender and slope of the line
- Figure 5. Graphs and Regression Equations of Five Tests Isometric Muscle Strength Results
- Figure 6. Third degree isometric muscle strength charts for males, females and all individuals
- Figure 7. Four categories of common cubic isometric muscle strength graphss among volunteers

Tables Captions

- Table 1. Result Abbreviations
- Table A.1. Fitted Nonlinear Curves of Isometric Muscle Strength for 31 Volunteers

Figure 1

Figure 2

	Men ($MMT_i \pm SD$)	Women ($FMT_i \pm SD$)	All ($TMT_i \pm SD$)
$T_{1(0)} \text{ (gr.f)}$	33055.3 ± 16855.4	12025.0 ± 6111.11	24914.5 ± 17105.1
$T_{2(60)} \text{ (gr.f)}$	32065.8 ± 13295.1	12783.3 ± 5574.71	24601.6 ± 14443.2
$T_{3(30)} \text{ (gr.f)}$	33693.7 ± 16922.1	13175.0 ± 5934.40	25751.0 ± 16968.9
$T_{4(15)} \text{ (gr.f)}$	31331.6 ± 13960.1	14462.5 ± 5645.56	24801.6 ± 14084.8
$T_{5(10)} \text{ (gr.f)}$	30936.8 ± 13568.3	13716.7 ± 5761.92	24271.0 ± 13976.1

Figure 3

(Male)

(Female)

Figure 4

No.	X	Y	Regression Line Equation	R – Sq	Pearson Correlation Coefficient
a	$T_{1(0)}$	$T_{2(60)}$	$Y = 4896 + 0.7909X$	% 87.7	0.937
b	$T_{1(0)}$	$T_{3(30)}$	$Y = 2702 + 0.9251X$	% 87.0	0.933
c	$T_{1(0)}$	$T_{4(15)}$	$Y = 5930 + 0.7575X$	% 84.6	0.920
d	$T_{1(0)}$	$T_{5(10)}$	$Y = 5855 + 0.7392X$	% 81.8	0.905
e	$T_{2(60)}$	$T_{3(30)}$	$Y = -1606 + 1.112X$	% 89.6	0.946
f	$T_{2(60)}$	$T_{4(15)}$	$Y = 2954 + 0.8881X$	% 82.9	0.911

No.	X	Y	Regression Line Equation	R – Sq	Pearson Correlation Coefficient
g	$T_{2(60)}$	$T_{5(10)}$	$Y = 2280 + 0.8939X$	% 85.3	0.924
h	$T_{3(30)}$	$T_{4(15)}$	$Y = 4142 + 0.8023X$	% 93.4	0.967
i	$T_{3(30)}$	$T_{5(10)}$	$Y = 3954 + 0.7890X$	% 91.8	0.958
j	$T_{4(15)}$	$T_{5(10)}$	$Y = -6.2 + 0.9789X$	% 97.3	0.986
k	$t(\text{sec})$	MMT_t	$Y = 33220 - 13.56X$	% 29.6	- 0.544
l	$t(\text{sec})$	FMT_t	$Y = 11914 + 17.82X$	% 79.8	0.893
m	FMT_t	MMT_t	$Y = 42841 - 0.8029X$	% 41.3	- 0.642

Figure 5

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No.	X	Y	Nonlinear Regression Equation	R - Sq	R - Sq (adj)
n	t (sec)	MMT	$MMT = 33047 - 182.2t + 4.33t^2 - 0.03t^3$	% 79.2	% 16.9
o	t (sec)	FMT	$FMT = 12031 - 23.0t + 0.81t^2 - 0.004t^3$	% 83.1	% 32.4
p	t (sec)	TMT	$TMT = 24912 - 120.6t + 2.97t^2 - 0.017t^3$	% 89.9	% 59.4

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Figure 6

No.	Nonlinear Regression Equation	$R - Sq$	$R - Sq (adj)$
I	$IMS_I = 26272 + 470.5t - 10.37t^2 + 0.05t^3$	% 98.8	% 95.3
II	$IMS_{II} = 27358 - 662.7t + 15.37t^2 - 0.08t^3$	% 94.4	% 77.8
III	$IMS_{III} = 14946 + 379.1t - 6.33t^2 + 0.03t^3$	% 98.1	% 92.6
IV	$IMS_{IV} = 19535 + 101.0t - 2.01t^2 + 0.008t^3$	% 96.2	% 84.9

Figure 7

Tables

Table 1

$T_{1(0)}$: Initial measurement	MMT_i : Average measurements for males in i th test
$T_{2(60)}$: Second measurement after 1 minute rest	FMT_i : Average measurements for females in i th test
$T_{3(30)}$: Third measurement after 30 seconds rest	TMT_i : Average measurements for all volunteers in i th test
$T_{4(15)}$: Fourth measurement after 15 seconds rest	t : Time (Second)
$T_{5(10)}$: Fifth measurement after 10 seconds rest	IMS_i : Isometric Muscle Strength of the i th volunteer

Table A.1

Volunteer Number	Nonlinear Regression Equation	R-Sq	R-Sq (adj)
1	$IMS_1 = 23271 + 658.2t - 12.99t^2 + 0.06t^3$	75.6%	2.5%
2	$IMS_2 = 16897 + 183.1t - 2.4t^2 + 0.01t^3$	99.4%	97.6%
3	$IMS_3 = 12802 - 35.2t + 0.83t^2 + 0.003t^3$	96.6%	86.5%
4	$IMS_4 = 4659 + 101.5t - 3.18t^2 + 0.02t^3$	84.6%	38.5%
5	$IMS_5 = 39290 + 616.2t - 13.05t^2 + 0.07t^3$	95.4%	81.5%
6	$IMS_6 = 36460 - 670.7t + 13.75t^2 - 0.07t^3$	96.9%	87.6%
7	$IMS_7 = 21261 + 1085t - 18.3t^2 + 0.09t^3$	99.0%	95.8%
8	$IMS_8 = 34682 + 399.5t - 7.84t^2 + 0.03t^3$	92.0%	67.9%
9	$IMS_9 = 61882 - 1801t + 38.84t^2 - 0.20t^3$	98.4%	93.7%
10	$IMS_{10} = 24407 + 43.0t - 0.63t^2 + 0.004t^3$	87.0%	48.0%
11	$IMS_{11} = 67202 - 842.3t + 21.35t^2 - 0.13t^3$	88.3%	53.4%
12	$IMS_{12} = 28326 + 346.8t - 1.75t^2 + 0.07t^3$	86.5%	46.0%
13	$IMS_{13} = 22298 + 221.7t - 4.26t^2 + 0.02t^3$	98.9%	95.8%
14	$IMS_{14} = 24094 - 324.6t + 8.25t^2 - 0.05t^3$	97.7%	90.9%
15	$IMS_{15} = 27182 - 869.1t + 21.16t^2 - 0.12t^3$	91.5%	65.9%
16	$IMS_{16} = 39786 + 878.3t - 18.77t^2 + 0.09t^3$	97.6%	90.4%
17	$IMS_{17} = 12948 - 12.77t + 0.65t^2 - 0.006t^3$	98.5%	94.1%
18	$IMS_{18} = 52272 - 986.0t + 12.33t^2 - 0.05t^3$	98.7%	94.6%
19	$IMS_{19} = 8998 - 208.3t + 4.81t^2 - 0.03t^3$	99.1%	96.5%
20	$IMS_{20} = 19540 - 33.8t - 0.06t^2 + 0.004t^3$	75.7%	2.6%
21	$IMS_{21} = 61529 - 1377t + 31.08t^2 - 0.17t^3$	64.4%	0.0%
22	$IMS_{22} = 16676 + 58.0t - 1.33t^2 + 0.003t^3$	40.0%	0.0%
23	$IMS_{23} = 10685 - 156.7t + 6.22t^2 - 0.04t^3$	88.0%	52.0%
24	$IMS_{24} = 25911 + 114.3t - 1.52t^2 + 0.006t^3$	69.1%	0.0%
25	$IMS_{25} = 4613 + 265.0t - 5.28t^2 + 0.03t^3$	90.6%	62.6%
26	$IMS_{26} = 22063 + 75.9t - 1.54t^2 + 0.006t^3$	60.3%	0.0%
27	$IMS_{27} = 6050 + 248.1t - 4.16t^2 + 0.02t^3$	100%	100%
28	$IMS_{28} = 13659 - 216.8t + 5.57t^2 - 0.03t^3$	83.8%	35.1%
29	$IMS_{29} = 13753 - 359.8t + 8.21t^2 - 0.04t^3$	99.7%	98.8%
30	$IMS_{30} = 11306 - 15.5t + 0.01t^2 + 0.0004t^3$	59.3%	0.0%
31	$IMS_{31} = 7767 - 144.4t + 5.05t^2 - 0.03t^3$	78.0%	12.1%