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Development of Linear Regression models for estimating total body isometric strength (Relative Strength approach)

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Abstract

This study has been conducted to develop linear regression Models for computing total body relative isometric strength. Total 67 male subjects have been selected randomly from Delhi region with Decimal Age (20.68 ± 1.52), Height (169.25 ± 7.24), Weight (60.92 ± 9.84) and BMI (21.20 ± 2.56). They carried out three trials of each of isometric strength tests namely Hand grip strength test, leg strength dynamometer test and back strength dynamometer test. For data analysis the mean values of the three trials have been considered as reliable data. Standard test administration protocols have been followed and standard equipments (JAMAR hand grip dynamometer and TAKAI leg and back strength dynamometer) have been used for reliable and valid test results. Pearson correlation coefficients have been computed for measuring the relationship among strength variables and linear models have been developed through Linear Regression Modeling. **Results:** Total 17 Linear Models have been developed, among which two models have shown very high predicting capability of total body relative strength namely, Model (M13) with relative leg strength as predictor variable and having R2 = 0.800 and F = 260.086 and M15 with relative back strength as predictor variable and R2 = 0.484; F = 60.962.

Key Word: Regression Linear modeling, Isometric Strength tests, Relative Strength, Strength Evaluation

1. Introduction:

Human being is a very busy creature of our planet Earth and in today's modern world every human has to face challenges in every aspect of life whether its professional field or house hold activities, difficulties and challenges are everywhere. To overcome this all challenges and difficulties efficiently and to live the life at its fullest every person need to be physically and mentally fit. Being physically fit is a very complex phenomenon and need different type of fitness for different activities but at the end of the day every type of physical fitness is based on some basic components of physical fitness such as strength, endurance, speed and flexibility etc. Among all these components strength is considered as one of the most important component of fitness as every type of physical activity even occurring for seconds require strength in some form or other. There are various ways to increase and maintain strength of different types such as maximum strength and explosive strength but unless you are an athlete and professional player you won't need them that often unless some emergency occurs. For regulating the strength at optimum level and to maintain the fitness level frequent evaluation of strength becomes necessary. There are various ways to measure and predict the overall strength of our body but the best reliable and valid ways are isometric strength tests such as hand grip strength, leg strength dynamometer test, back strength dynamometer test etc.These tests are quick, convenient and inexpensive and provide us with a general indication of total body strength levels. The three mentioned isometric strength tests have been found to be very reliable and valid for measuring and predicting the isometric strength of specific body part strength and total body strength as whole as well.Since strength is a physical fitness component, it must be related to each individual and it should be measured in relation to the individual's body weight.

Many researches have been conducted regarding the measurement and prediction of total body absolute strength through linear regression models and the models have found to be very accurate but the models for predicting total body relative strength is lacking in research literature, therefore our study will serve as a pioneer study for

predicting total body relative strength. Wind and taken found that Grip strength has a strong relationship with total muscle strength and reported coefficients between 0.736 and 0.890 ($p < 0.01$). They concluded that in the clinical setting grip strength test is a good source for measuring someone's general muscle strength [(Wind, T, PJ, &RH, 2014)]. In their study Tosclair and Judgefound that hand grip strength has a significant relationship with total body absolute strength and muscle endurance with correlations between hand grip strength and sit ups test ($r = .472$, $p \leq .001$), hand grip strength and push up test ($r = .241$, $p = .047$) for muscle endurance, hand grip strength and 1RM leg extension ($r = .718$, $p \leq .001$), hand grip strength and 1RM leg press ($r = .609$, $p \leq .001$) for muscular strength (D, Bellar, Judge, Smith, Mazerat, & Brignac, 2011).

2. Methods and Materials:

In our study total 67 male subjects were selected randomly from NCR, Delhi with Decimal Age (20.68 ± 1.52), Height (169.25 ± 7.24), Weight (60.92 ± 9.84) and BMI (21.20 ± 2.56). The subjects were indulged in three strength tests namely Hand grip strength test, leg strength and back strength tests. The mean values of all the three trials of each test have been used for the calculation. . For reliable and valid test results, tests were administered with standard protocols and with standard equipments. To calculate the relationship among the strength variables Pearson Correlation Coefficients were computed and the Linear Models were developed through Linear regression Modeling.

2.1 Equipments Used: In our study we have used two standard equipments for measuring the three strength tests, their brief descriptions are given below:

I. **JAMAR** Hand Grip Dynamometer (Made in USA) for measuring hand grip strength.
II. **BACK-D** (Produced by TAKEI, Made in Japan), Back and Leg Strength Dynamometer for measuring back and leg strength.

2.2 Test Administration:

i. Handgrip Strength Test

- **Procedure:** The subjects hold the dynamometer in the hand to be tested, with their arms at right angles and the elbow by the side of the body. The handle of the dynamometer was adjusted if required and they were supervised that the base of the hand grip dynamometer should rest on first metacarpal (heel of palm), while the handle should rest on middle of four fingers. When ready the subject squeezed the dynamometer with maximum isometric effort, which was maintained for about five seconds. No other body movement or support was allowed. The subjects were strongly encouraged to give a maximum effort. The test was conducted after proper warming up.
- **Scoring:** Three trials for each hand were recorded (Topend Sports, Hand grip strength).

ii. Leg and Back Strength Test:

- **Procedure**: Before conducting the test it was made sure that the dial is reset to zero. The subjects were supervised to stand upright on the base of the dynamometer with their feet shoulder width apart. Then for measuring the back strength subjects bend their back, pulled as hard as possible on the chain and tried to straighten their back, keeping the arms straight until their back became straight. Same procedure was applied for measuring the leg strength but in that case the back was not bend and kept fixed while legs exerted the force and the test was performed till both the legs were straightened at maximum possible.
- **Scoring**: Three trials have been taken and the average of the three trials was considered for analysis (Topend sportrs, Isometric Leg Strength).

3. Findings of the Study:

The findings of our study have been documented in the following Tables and figures as below:

Table-1

Descriptive Statistics of the Selected Variables of the Male Subjects from Delhi-NCR Region

S.N0	Independent Variable Name	Symbol	Mean	S.D
1.	Decimal Age (Years)	DA	20.67	1.52
2.	Body Weight (Kgs)	WT.	60.92	9.84
3.	Height (cms)	HT	169.25	7.24
4.	Body Mass Index	BMI	21.20	2.56
5.	Right Grip Strength (Kgs)	RGS	41.14	6.52
6.	Right Grip Strength per Kg (Kgs)	RRS	0.68	0.084
7.	Left Grip Strength (Kgs)	LGS	39.73	6.54
8.	Left Grip Strength per Kg (Kgs)	LRS	0.657	0.087
9.	Sum of Right and Left Grip Strength (Kgs)	RLT	80.86	12.67
10.	Right and Left Grip Strength Difference(Kgs)	RLD	2.78	1.99
11.	Right and Left Grip Strength Percentage Difference (Kgs)	RLPD	6.72	4.46
12.	Leg Strength (Kgs)	LST	128.99	39.35
13.	Leg strength per Kg (Kgs)	LRST	2.12	0.544
14.	Back Strength (Kgs)	BST	104.68	19.75
15.	Back Strength per Kg (Kgs)	BRST	1.73	0.24
16.	Leg and Back Strength Difference (Kgs)	LBD	30.54	25.35
17.	Leg and Back Strength Percentage Difference (Kgs)	LBPD	21.78	15.66
18.	Total Relative Strength (Kgs)	TRS	5.179	0.728

(RGS+LGS+LST+BST) / Body Weight (WT) = (TRS) was selected as Criterion Dependent Variable

In the Table-1, the abbreviations and Descriptive Statistics of different variables of Delhi-NCR Male Youth population have been documented with DA (20.67±1.52), WT (60.92±9.84), HT (169.25±7.24), BMI (21.20±2.56), RGS(41.14±6.52), RPW (0.68±0.084), LGS(39.73±6.54), LPW(0.657±0.087), RLT (80.86±12.67), RLD (2.78±1.99), RLPD

(6.72±4.46), LST (128.99±39.35), LPWT (2.12±0.544), BST (104.68±19.75), BPWT (1.73±0.24), LBD (30.54±25.35), LBPD (21.78±15.66) and TRS (5.179±0.728) have been documented.

Table – 2
Pearson Correlations among the Selected physical and strength Variables

	DA	WT	HT	BMI	RGS	RPW	LGS	LPW	RLT	RLD	RLPD	LST	LPWT	BST	BPWT	LBD	LBPD
DA	1	.058	-.138	.197	-.118	-.260*	-.090	-.207	-.107	-.186	-.212	.062	.067	.004	-.058	.095	.046
WT	.058	1	.636**	.838**	.662**	-.372**	.652**	-.354**	.677**	.083	-.072	.559**	.003	.695**	-.181	.307*	.116
HT	-.138	.636**	1	.119	.466**	-.165	.504**	-.108	.499**	.044	-.069	.203	-.204	.499**	-.036	.061	.003
BMI	.197	.838**	.119	1	.545**	-.347**	.497**	-.372**	.537**	.073	-.052	.559**	.126	.549**	-.203	.334**	.140
RGS	-.118	.662**	.466**	.545**	1	.435**	.885**	.301*	.971**	.285*	.050	.461**	.108	.669**	.164	.172	.036
RPW	-.260*	-.372**	-.165	-.347**	.435**	1	.317**	.816**	.387**	.257*	.157	-.085	.141	.010	.442**	-.150	-.103
LGS	-.090	.652**	.504**	.497**	.885**	.317**	1	.469**	.971**	.066	-.126	.436**	.082	.634**	.128	.124	-.022
LPW	-.207	-.354**	-.108	-.372**	.301*	.816**	.469**	1	.397**	-.011	-.062	-.105	.102	-.024	.375**	-.200	-.165
RLT	-.107	.677**	.499**	.537**	.971**	.387**	.971**	.397**	1	.180	-.039	.462**	.098	.671**	.150	.152	.007
RLD	-.186	.083	.044	.073	.285*	.257*	.066	-.011	.180	1	.953**	.035	-.049	.149	.084	.058	.073
RLPD	-.212	-.072	-.069	-.052	.050	.157	-.126	-.062	-.039	.953**	1	-.118	-.126	-.040	.004	-.016	.052
LST	.062	.559**	.203	.559**	.461**	-.085	.436**	-.105	.462**	.035	-.118	1	.824**	.611**	.201	.762**	.403**
LPWT	.067	.003	-.204	.126	.108	.141	.082	.102	.098	-.049	-.126	.824**	1	.263*	.362**	.711**	.419**
BST	.004	.695**	.499**	.549**	.669**	.010	.634**	-.024	.671**	.149	-.040	.611**	.263*	1	.576**	.286*	.150
BPWT	-.058	-.181	-.036	-.203	.164	.442**	.128	.375**	.150	.084	.004	.201	.362**	.576**	1	.053	.089
LBD	.095	.307*	.061	.334**	.172	-.150	.124	-.200	.152	.058	-.016	.762**	.711**	.286*	.053	1	.871**
LBPD	.046	.116	.003	.140	.036	-.103	-.022	-.165	.007	.073	.052	.403**	.419**	.150	.089	.871**	1
ASCC (∑r)	1.905	6.265	3.754	5.488	6.328	4.444	6.003	4.068	6.305	2.586	2.148	5.886	3.685	5.83	3.106	4.352	2.695
Rank	17	3	11	7	1	8	4	10	2	15	16	5	12	6	13	9	14

Note: *Significant at **0.05** levels; **ASCC** = Absolute sum of score of all the correlation coefficients of every variable with all the variables.

In the **Table – 2** correlation coefficient matrix among all the selected physical and strength variables have been computed and Absolute sum of scores of all the correlation coefficients of every variable with all the variables have been derived to measure their overall strength of relationship with all the variables. The highest (ACCS) rank found with the variable right grip strength (RGS), (∑ = 6.328) followed by sum of right and left hand grip strength (RLT) with (∑ = 6.305); body weight (WT) with (∑ = 6.265); left grip strength (LGS) with (∑ = 6.003); leg strength (LST) with (∑ = 5.886) and back strength (BST) with (∑ = 5.83).

Table-3
Pearson Correlation Coefficient between Independent Variable and Total Body Relative Strength (Dependent Variable)

S.NO	Predictor Variable	Pearson Correlation Coefficient
1	DA	-0.023 NS
2	WT.	-0.142 NS
3	HT	-0.196 NS
4	BMI	-0.057 NS
5	RGS	0.220*
6	RPW	0.464*
7	LGS	0.196 NS
8	LPW	0.413*
9	RLT	0.215*
10	RLD	0.020 NS
11	RLPD	-0.082 NS
12	LST	0.659*
13	LPWT	0.894*
13	LPWT	0.894*
14	BST	0.385*
15	BPWT	0.696*
16	LBD	0.507*
17	LBPD	0.311*

Absolute Sum of Correlation Coefficients = 5.48

Note: *Significant at 0.05 levels; NS = Not Significant; Criterion Dependent Variable Total Relative Strength (TRS) = (RGS+LGS+LST+BST)/ WT

According to the Table-3, the Correlation Coefficient between Total Body Relative Strength and RGS (r = 0.220), RPW (r = 0.464), LPW (r = 0.413) RLT, LST (r = 0.659), LPWT (r = 0.894), BST (r = 0.385), BPWT (r = 0.696), LBD (r = 0.507) and LBPD (r = 0.311) respectively were found to be statistically significant. However, Coefficient of Correlation between Total Body Relative Strength and DA (r = -0.023), WT (r = -0.142) HT (r = -0.196), BMI (r = -0.057),LGS (r = 0.196), RLD (r = 0.020), RLPD (r = -0.082), respectively were found to be statistically insignificant.

Table-4
Linear Models Developed for Estimating Total Body Relative Strength of Delhi Males

Model	D.V	Constant	Linear Model Predictor	R	R2	S.E. of the Estimate	F
1	TRS	= 5.410	- 0.011 (DA)	.023	.001	0.734	0.035 NS
2	TRS	= 5.821	- 0.011 (WT)	.142	.020	0.726	1.345 NS
3	TRS	= 8.512	- 0.020 (HT)	.196	.038	0.720	2.589 NS
4	TRS	= 5.522	- 0.016 (BMI)	.057	.003	0.733	0.210 NS
5	TRS	= 4.166	+ 0.025 (RGS)	.220	.049	0.716	3.321 NS
6	TRS	= 2.447	+4.017 (RPW)	.464	.215	0.650	17.797*
7	TRS	= 4.311	+ 0.022 (LGS)	.196	.038	0.719	2.601 NS
8	TRS	= 2.903	+3.464 (LPW)	.413	.171	0.668	13.398*
9	TRS	= 4.183	+0.012 (RLT)	.215	.046	0.717	3.136*
10	TRS	= 5.159	+ 0.007 (RLD)	.020	.000	0.734	0.025 NS
11	TRS	= 5.270	- 0.013 (RLPD)	.082	.007	0.731	0.442 NS
12	TRS	= 3.607	+ 0.012 (LST)	.659	.434	0.552	49.832*
13	TRS	= 2.643	+ 1.198 (LPWT)	.894	.800	0.328	260.086*
14	TRS	= 3.694	+ 0.014 (BST)	.385	.148	0.677	11.293*
15	TRS	= 1.539	+ 2.110 (BPWT)	.696	.484	0.527	60.962*
16	TRS	= 4.734	+ 0.015 (LBD)	.507	.257	0.632	22.517*
17	TRS	= 4.865	+ 0.014 (LBPD)	.311	.096	0.697	6.936*

Note: *Significant at 0.05 levels, NS = Not Significant**,** Total Relative Strength TRS = (RGSA+LGSA+LDA+BDA)/ WT

Table-4depicts strongest Linear Model (M13) for predicting TRS with R^2 = 0.800 and F = 260.086* followed by M15 with R^2 = 0.484 and F = 60.962*, M12 with R^2 = 0.434 and F = 49.832*, M16 with R^2 = 0.257 and F = 22.517*, M6 with R^2 = 0.215 and F = 17.797*, M8 with R^2 = 0.171 and F = 13.398*, M14 with R^2 = 0.148 and F = 11.293*, M17 with R^2 = 0.096 and F = 6.936*. However The Linear Model M10has the least prediction value of Total Body Strength with R^2 = 0.000 and F = 0.025 NS, followed by M1 with R^2 = 0.001 and F = 0.035 NS, M4 with R^2 = 0.003 and F = 0.210 NS, M11 with R^2 = 0.007and F = 0.442 NS and M2 with R^2 = 0.020 and F = 1.345 NS.M3 with R^2 = 0.038 and F = 2.589 NS, M7 with R^2 = 0.038 and F = 2.601 NS, M9 with R^2 = 0.046 and F = 3.136 NS, M5 with R^2 = 0.049 and F = 3.321 NS.A Partial Regression Plot of our 2best models (Model 13 and 15) with independent variables (Predictor variable) Relative Leg Strength (LPWT) and Relative Back Strength (BPWT)and dependent variable Total body Relative Strength (TRS) has been graphically represented below in the figures 1 and 2 respectively:

Figure – 1

Regression plot of Model 13 with dependent variable Relative Leg strength with total body Relative strength

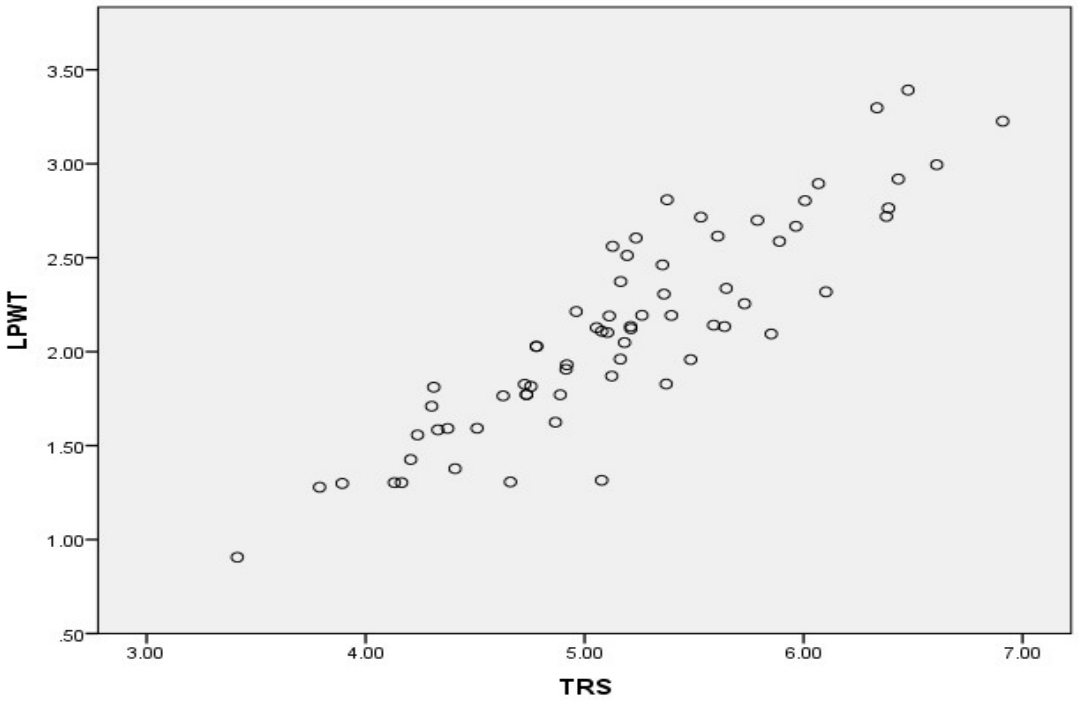
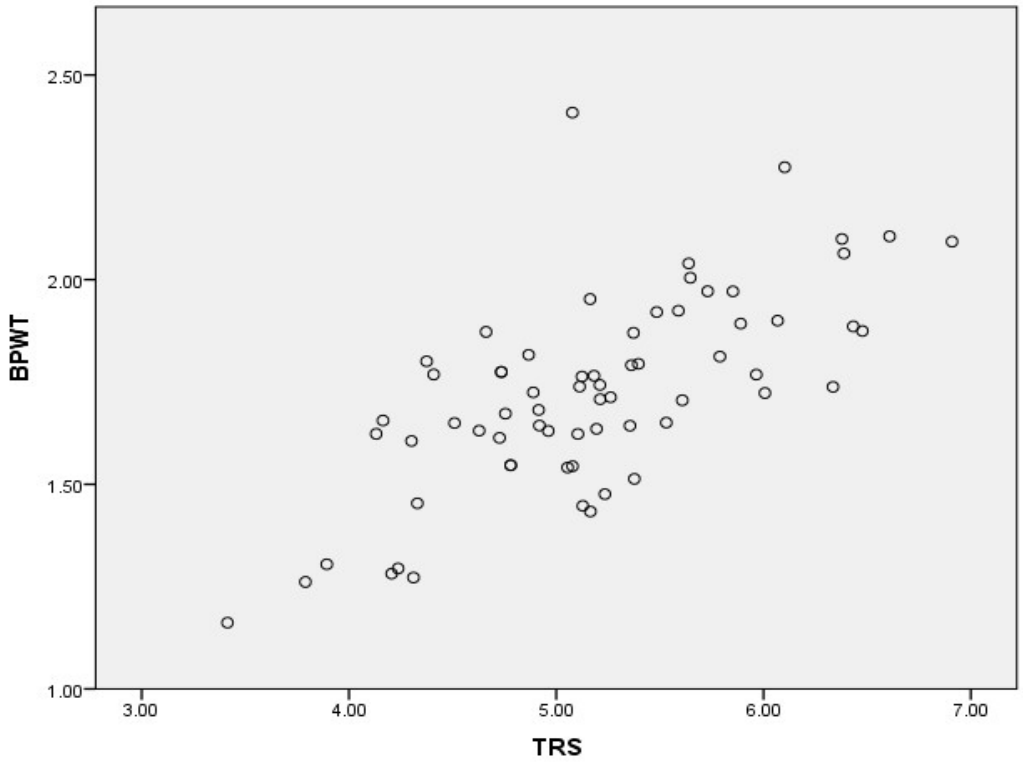


Figure – 2

Regression plot of Model 15 with dependent variable Relative Back Strength with total body Relative strength.



4. Results and Discussion:

The criterion dependent variable total body relative strength (TRS) is the sum of strength of right grip, left grip, leg strength and back strength divided by total body weight is well justified because the absolute sum of the correlation coefficients of TRS (∑ =5.48) is quite high among all selected variables.

Total 17 Linear Regression Models have been developed among which two models have shown very high predicting capability of total body strength namely, Model (M13) with leg strength as predictor variable and having R^2 = 0.800 and F = 260.086* and M15 with back strength as predictor variable and R^2 = 0.484; F = 60.962*. The regression models are TRS = 2.643 + 1.198 (LPWT) and TRS = 1.539 + 2.110 (BPWT). The reason behind is that the linear relationship between the dependent variable total body relative strength (TRS) and independent variables relative leg strength (LPWT) and relative back strength (BPWT) is very high.

The results of our study show that relative leg strength and relative back strength can be considered good predictors of total body relative strength. In previous studies various researchers namely (D, et al., 2011) and (Wind, T, PJ, & RH., 2014) have found out that grip strength is a good predictor of total body strength with correlation coefficients between 0.736 and 0.890 but similar researches regarding the relative strength is strangely absent in research literature. In our case the correlation of total body relative strength with right and left grip strengths were very low (r = 0.220, (r = 0.196) but when the relationship of relative grip strength and total body relative strength were taken into account it increased significantly in both hands (r = 0.464, (r = 0.413) respectively, moreover correlation of right and left hand relative grip strengths were insignificant with relative leg strength (r = 0.141); (r = 0.102) but were significant with relative back strength (r = 0.442); (r = 0.375). However the ASCC (∑r) showed that right hand grip strength ranked first (∑r = 6.328) followed by right and left total grip strength (∑r = 6.305), body weight (∑r = 6.265), left hand grip strength (∑r = 6.003), leg strength (∑r = 5.886) and back strength (∑r = 5.83). Keeping in view the absence of related literature and the overall relationship (ASCC) of right hand grip strength we can say that grip strength and can be a good predictor of total body absolute strength but their relationship with total body relative strength is very insignificant so they can't be considered as good predictor of total body relative strength (TRS).

5. Conclusion:

Based upon the analysis we suggest following two models for predicting total body relative strength: TRS = 2.643 + 1.198 (LPWT); TRS = 1.539 + 2.110 (BPWT).

6. References:

[1]. D, T., Bellar, D., Judge, L. W., Smith, J., Mazerat, N., & Brignac, A. (2011, March). Hand-Grip Strength as a Predictor of Muscular Strength and Endurance. Retrieved feburary 20, 2018, from The Journal of Strength and Conditioning Research: https://journals.lww.com/nsca-jscr/Abstract/2011/03001/Hand_Grip_Strength_as_a_Predictor_of_Muscular.156.aspx?WT.mc_id=HPxADx20100319xMP

[2]. Helen C. Roberts, H. J. (2011). A review of the measurement of grip strength in clinical and epidemiological studies: towards a standardised approach. Age aging, 423-429.

[3]. Lucy Jawan, R. A. (2014, july 2014). Efficacy of Handgrip Strength in Predicting Total Body Strength Among High Performance Athletes. Retrieved feb 22, 2018, from springer link: https://link.springer.com/chapter/10.1007/978-981-287-107-7_4

[4]. Philosophy, A. h. (2015, january 9). muscular strength. Retrieved feburary 20, 2018, from A healthy Philosophy: https://www.ahealthyphilosophy.com/article/muscular-strength

[5]. sportrs, t. (n.d.). isometric leg strength . Retrieved feburary 20, 2018, from topendsports.com: http://www.topendsports.com/testing/tests/isometric-strength.htm

[6]. Sports, T. (n.d.). hand grip strength. Retrieved feburary 20, 2018, from topendsports.com: http://www.topendsports.com/testing/tests/handgrip.htm

[7]. TeachPE.com, 2. (n.d.). types_of_muscle_contractions. Retrieved feburary 20, 2018, from http://www.teachpe.com: http://www.teachpe.com/anatomy/types_of_muscle_contractions.php

[8]. Wind, A., T, T., PJ, H., & RH., E. (2014, june). Is grip strength a predictor for total muscle strength in healthy children, adolescents, and young adults? Retrieved feburary 20, 2018, from pubmed: https://www.ncbi.nlm.nih.gov/pubmed/19526369

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