Handgrip strength correlates with insulin resistance and the metabolic syndrome in children and adolescents: Analysis of the Korean National Health and Nutrition Examination Survey 2014-2016

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OBJECTIVES

- Progressive loss of muscle mass in adults is associated with increased morbidity, disability and mortality. Muscular fitness in children has been inversely associated with adiposity, cardiovascular disease and metabolic risk factors.
- Handgrip strength (HGS) is an indicator of muscle strength and has been correlated with total muscle strength in children and adolescents.

AIMS:

1. To evaluate the association between handgrip strength and components of the metabolic syndrome (waist circumference, blood pressure, triglycerides, high density lipoprotein (HDL) cholesterol, and fasting glucose).
2. To evaluate the association between handgrip strength and measures of insulin resistance (fasting insulin and homeostatic model assessment of insulin resistance (HOMA-IR)).

SUBJECTS

2242 children and adolescents aged 10-18 years who participated in the Korean National Health and Nutrition Examination Survey (KNHANES) between 2014 to 2016 were eligible for analysis.

Exclusion criteria:

- Absence of handgrip strength measurements (n = 261)
- Absence of anthropometric measurements (n = 166)
- Absence of measures of metabolic syndrome components (n = 485)
- Fasting less than 8 hours (n = 260)
- Diagnosed with diabetes or fasting glucose levels ≥ 126 mg/dL

Included for analysis: 1646 participants (884 males, 762 females) were included in the analysis

METHODS

Measurement of handgrip strength:

- Digital grip hand dynamometer (Model T.K.K.5401, Takei, Japan)
- Standing position with feet hip width apart, arms straight down, elbows fully extended and wrist in neutral position
- Maximum grip strength for < 3 seconds (3 times for both right and left hands; with 30 seconds resting intervals)

Grip strength analysis:

- Combined handgrip strength (CHGS): sum of the largest reading from each hand in kilograms (kg)
- Normalized combined handgrip strength (nCHGS): CHGS in kg per body weight in kg

Outcome variables:

- **Metabolic syndrome and its components:** IDF definition
  Abdominal obesity (WC >90th percentile or adult cutoff if lower) and 2 or more of the following components: Fasting glucose ≥100 mg/dL; Triglycerides ≥150 mg/dL; HDL <40 mg/dL (for both males and females aged 10-16 years); <50 mg/dL (for females aged ≥16 years); Blood pressure (BP): SBP ≥130 mmHg or DBP ≥85 mmHg)

2) Insulin resistance: **HOMA-IR, fasting insulin**

- Data available only for 2015 (subgroup analysis n = 555)

RESULTS

Table 1. Baseline characteristics and measurements of handgrip strength, metabolic syndrome components and insulin resistance

	Total (n= 1645)	Male 884 (53.5%)	Female 762 (46.5%)	*P*-value
Baseline characteristics				
Age, yr	14.4 ± 0.1	14.4 ± 0.1	14.3 ± 0.1	0.445
Height z-score	0.18 ± 0.03	0.18 ± 0.04	0.17 ± 0.05	0.883
BMI z-score	0.06 ± 0.04	0.04 ± 0.06	0.09 ± 0.05	0.566
Obesity, n (%)	198 (12.3%)	117 (13.3%)	81 (11.3%)	0.260
Vigorous PA (min/day)	6.5 ± 0.7	10.0 ± 1.2	2.5 ± 0.5	< 0.001
Moderate PA (min/day)*	5.9 ± 0.5	7.7 ± 0.8	3.9 ± 0.4	< 0.001
Moderate-vigorous PA (min/day)*	12.4 ± 1.0	17.7 ± 1.7	6.4 ± 0.8	< 0.001
Sedentary time (hour/day)*	10.7 ± 0.1	10.4 ± 0.1	11.1 ± 0.1	< 0.001
Measures of Handgrip Strength				
Combined handgrip strength (CHGS), kg*	53.3 ± 0.6	61.8 ± 0.8	43.6 ± 0.4	< 0.001
Normalized CHGS (nCHGS), kg/kg*	0.95 ± 0.01	1.04 ± 0.01	0.85 ± 0.01	< 0.001
Metabolic syndrome components				
Waist circumference, cm *	71.4 ± 0.3	73.6 ± 0.4	68.8 ± 0.4	< 0.001
SBP, mmHg *	108.6 ± 0.3	110.9 ± 0.4	106.1 ± 0.4	< 0.001
DBP, mmHg *	66.4 ± 0.2	66.9 ± 0.3	65.8 ± 0.3	0.006
Fasting glucose, mg/dL *	91.6 ± 0.2	92.6 ± 0.3	90.3 ± 0.3	< 0.001
HbA1c, %	5.36 ± 0.01	5.38 ± 0.01	5.36 ± 0.01	0.089
Triglyceride, mg/dL	75.5 ± 1.1	73.8 ± 1.5	77.5 ± 1.5	0.063
HDL cholesterol, mg/dL *	50.9 ± 0.3	49.7 ± 0.4	52.3 ± 0.4	< 0.001
Abdominal obesity, n (%)	208 (12.9%)	109 (12.3%)	99 (13.7%)	0.425
Elevated fasting glucose, n (%) *	181 (11.0%)	119 (13.6%)	62 (8.0%)	0.002
Elevated blood pressure, n (%) *	64 (3.7%)	51 (5.5%)	13 (1.7%)	< 0.001
Elevated triglyceride, n (%)	130 (7.9%)	71 (8.1%)	59 (7.7%)	0.819
Low HDL-C, n (%) *	243 (14.9%)	10 (10.8%)	143 (19.7%)	< 0.001
Metabolic syndrome (IDF), n (%)	40 (2.7%)	23 (2.9%)	17 (2.5%)	0.693
Measures of insulin resistance	Total (n = 555)	Male (n = 305)	Female (n = 250)	*P*-value
Insulin, μIU/mL	11.0 ± 0.3	10.6 ± 0.4	11.4 ± 0.4	0.104
HOMA-IR	2.47 ± 0.08	2.40 ± 0.10	2.55 ± 0.10	0.240

Figure 1. Quartiles of nCHGS and measures of insulin resistance

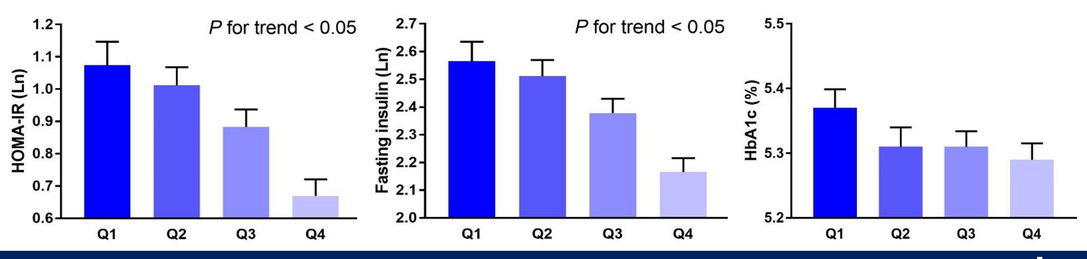
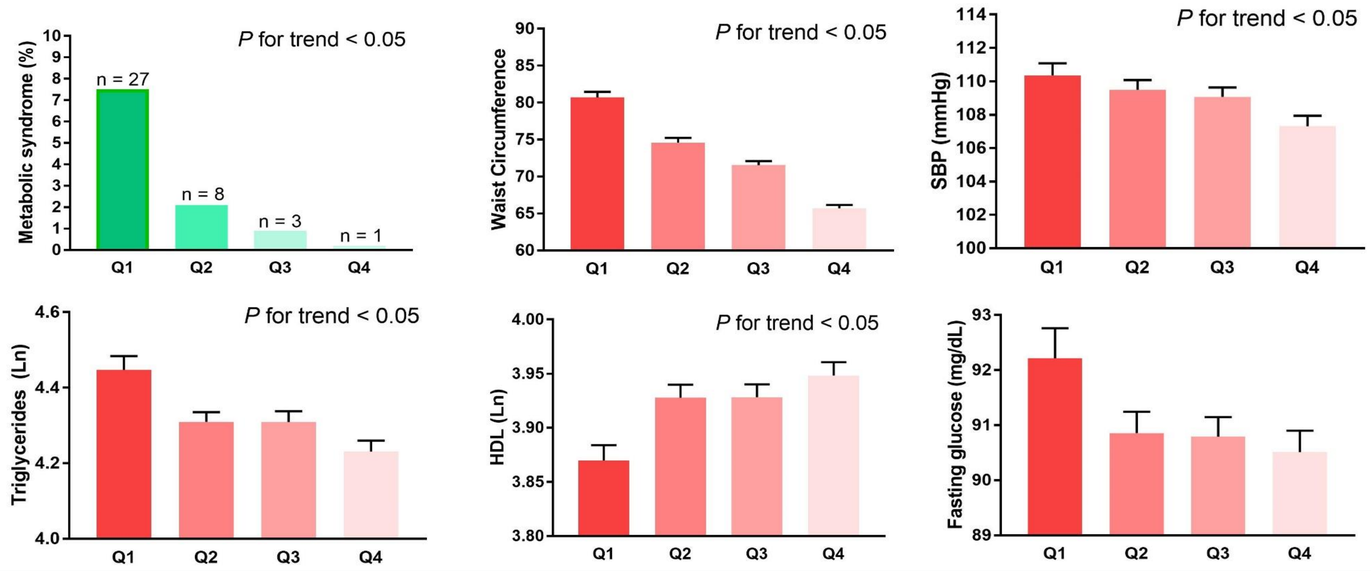


Table 2. Linear regression: Handgrip strength, metabolic syndrome components, and insulin resistance

		Simple			Multiple (Model 1)*			Multiple (Model 2)**		
Dependent Variables	Independent Variables	Coef	S.E.	P	Coef	S.E.	P	Coef	S.E.	P
CHGS	**Metabolic syndrome components**									
	WC	**0.809**	**0.047**	**<0.001**	0.142	0.089	0.110	-0.075	0.101	0.461
	SBP	**0.663**	**0.048**	**<0.001**	**0.161**	**0.039**	**<0.001**	**0.097**	**0.047**	**0.038**
	DBP	**0.650**	**0.060**	**<0.001**	**0.148**	**0.042**	**<0.001**	**0.121**	**0.045**	**0.008**
	Fasting glucose	0.005	0.076	0.952	0.004	0.049	0.933	-0.006	0.056	0.914
	Triglycerides	1.321	1.104	0.232	0.859	0.664	0.197	0.379	0.788	0.631
	HDL	**-21.10**	**2.558**	**<0.001**	**-6.181**	**1.693**	**<0.001**	-2.904	2.008	0.149
	Insulin resistance measures									
	HOMA-IR	-0.152	1.364	0.912	1.907	1.379	0.169	1.407	1.674	0.402
	Fasting insulin	-0.173	1.422	0.903	1.888	1.454	0.196	1.375	1.755	0.435
	HbA1c	-0.163	2.073	0.937	0.688	1.327	0.605	0.377	1.545	0.807
nCHGS	**Metabolic syndrome components**									
	WC	**-0.005**	**0.001**	**<0.001**	**-0.100**	**0.001**	**<0.001**	**-0.011**	**0.001**	**<0.001**
	SBP	**0.002**	**0.001**	**0.006**	**-0.020**	**0.001**	**<0.001**	**-0.003**	**0.001**	**<0.001**
	DBP	**0.003**	**0.001**	**<0.001**	0.001	0.001	0.956	0.001	0.001	0.695
	Fasting glucose	-0.001	0.001	0.171	**-0.002**	**0.001**	**0.033**	-0.002	0.001	0.111
	Triglycerides	**-0.052**	**0.014**	**<0.001**	**-0.041**	**0.011**	**<0.001**	**-0.046**	**0.014**	**0.001**
	HDL	-0.009	0.032	0.778	**0.091**	**0.028**	**0.001**	**0.134**	**0.033**	**<0.001**
	Insulin resistance measures									
	HOMA-IR	**-0.131**	**0.019**	**<0.001**	**-0.101**	**0.017**	**<0.001**	**-0.100**	**0.019**	**<0.001**
	Fasting insulin	**-0.141**	**0.020**	**<0.001**	**-0.109**	**0.017**	**<0.001**	**-0.107**	**0.020**	**<0.001**
	HbA1c	-0.024	0.026	0.340	-0.017	0.022	0.446	-0.001	0.026	0.998

TG, HDL, insulin and HOMA-IR were log transformed for the analyses. * Adjusted for sex, age, BMI for CHGS and sex and age for NCHGS. **Adjusted for sex, age, BMI, physical activity and sedentary time for CHGS and sex, age, physical activity and sedentary time for NCHGS.

Figure 2. Quartiles of nCHGS and the metabolic syndrome



SUMMARY OF RESULTS

nCHGS and components of the metabolic syndrome:

- Inverse correlation with WC, SBP, triglycerides
- Positive correlation with HDL cholesterol
- More metabolic syndrome in lower quartiles of nCHGS

nCHGS and insulin resistance:

- Inversely correated with HOMA-IR and fasting insulin

CONCLUSIONS

Normalized handgrip strength was significantly decreased for almost all components of the metabolic syndrome (abdominal obesity, blood pressure, triglycerides and HDL) as well as insulin resistance (HOMA-IR and fasting insulin).

Normalized handgrip strength may be useful in predicting the presence of cardiometabolic risk factors and insulin resistance in children and adolescents.