Nutrition 32 (2016) 228–235

Contents lists available at ScienceDirect

Nutrition

journal homepage: www.nutritionjrnl.com

Applied nutritional investigation

# Birth weight, intrauterine growth restriction and nutritional status in childhood in relation to grip strength in adults: from the 1982 Pelotas (Brazil) birth cohort

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ARTICLE INFO

*Article history:*
Received 10 June 2015
Accepted 14 August 2015

*Keywords:*
Cohort studies
Hand strength
Nutritional status
Birth weight

ABSTRACT

*Objective:* The aim of this study was to evaluate the association among birth weight, intrauterine growth, and nutritional status in childhood with grip strength in young adults from the 1982 Pelotas (Brazil) birth cohort.
*Methods:* In 1982, the hospital live births of Pelotas were followed. In 2012, grip strength was evaluated using a hand dynamometer and the best of the six measurements was used. Birth weight was analyzed as *z*-score for gestational age according to Williams (1982) curve. Weight-for-age, weight-for-length/height, and length/height-for-age at 2 and 4 y were analyzed in *z*-scores according to 2006 World Health Organization Child Growth Standards. Lean mass at 30 y was included as possible mediator using the g-computation formula.
*Results:* In 2012, 3701 (68.1%) individuals were interviewed and 3470 were included in the present analyses. An increase of 1 *z*-score in birth weight was associated with an increase of 1.5 kg in grip strength in males (95% confidence interval, 1.1–1.9). Positive effect of birth weight on grip strength was found in females. Grip strength was greater in individuals who were born with appropriate size for gestational age and positively associated with weight- and length/height-for-age *z*-score at 2 and 4 y of age. A positive association between birth weight and grip strength was only partially mediated by adult lean mass (50% and 33% of total effect in males and females), whereas direct effect of weight at 2 y was found only in males.
*Conclusions:* It is suggested that good nutrition in prenatal and early postnatal life has a positive influence on adult muscle strength. The results from birth weight were suggestive of fetal programming on grip strength measurement.


## Introduction

Grip strength has been associated with several outcomes. In the clinical environment, low hand-grip strength is associated with postoperative complications, hospital length of stay, and short-term survival, whereas in epidemiological studies, grip strength is inversely related to all-cause mortality, disability, and

RMB conceptualized the study, was responsible for the data collection of grip strength, conducted the statistical analysis, and wrote the manuscript. BLH coordinated the last follow-up with participants from the cohort, conducted the statistical analysis, and wrote the manuscript. DPG coordinated the last follow-up with participants from the cohort and wrote the manuscript. This article is based on data from the study Pelotas birth cohort, 1982 conducted by Postgraduate Program in Epidemiology at Universidade Federal de Pelotas. The 1982 birth cohort study was supported by the Wellcome Trust (grant number: 086974/Z/08/Z) Initiative entitled Major Awards for Latin America on Health Consequences of Population Change. Previous phases of the study were supported by the International Development Research Center, The World Health Organization (grant number: C6/370/17A), Overseas Development Administration, European Union, National Support Program for Centers of Excellence (PRONEX), the Brazilian National Research Council (CNPq) and Brazilian Ministry of Health.
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http://dx.doi.org/10.1016/j.nut.2015.08.014
0899-9007/

risk for fracture but is positively related to functional status and bone mass [1].

While it has long been known that lifestyle conditions affect physical capacity as well as health status, the fetal origins of adult disease hypothesis, also known as the Barker hypothesis, provides additional insights based on a biological programming theory in which conditions in the womb determine susceptibility to diseases in later life [2]. Thus, considerable attention has been devoted to within-lifetime adaptation of the organism, termed *phenotypic plasticity* [3], which supports that experience in earlier life may predict adult health status. In particular, growth patterns in fetal life, infancy, and childhood have been associated with the components of the metabolic syndrome (hypertension, type 2 diabetes, and cardiovascular disease), implicating early nutrition as the underlying mechanism [4–8].

Evidence suggests that birth weight may be related to muscle strength in adulthood. Results from a meta-analysis observed a pooled effect of 0.86 kg (95% confidence interval [CI], 0.58–1.15) increase in muscle strength (mainly evaluated by grip strength) per additional kg of birth weight, which is maintained across the life span [9]. On the other hand, the effect of nutritional status in infancy and childhood has been scarcely evaluated, with studies suggesting that poor early growth is related to low muscle strength in children, adults, and the elderly [10–12]. Possible mechanisms involved in this long-term adaptation may include the number and type of muscle fibers [13–15], in addition to processes regulated by satellite cells [16].

Most of the studies on the long-term consequences of birth weight on muscular strength come from high-income countries [9]. However, investigations regarding this subject are important from low- and middle-income countries (LMICs) because there is uncertainty about the biological pathways that link low birth weight and stunting in childhood to later disease outcomes, as well as a possible difference in body composition at a given birth weight between high- and low-income countries [17]. Thus, establishing whether nutritional status during developmental periods is associated to outcomes related to adult non-communicable diseases in LMICs in the same importance as in high-income countries is necessary [17].

Additionally, previous studies have not, to our knowledge, explored the mediating effect of the amount of lean mass in the relationship between early nutritional exposures and grip strength, especially regarding the use of adequate statistical tools. Recognizing these relationships may increase understanding of the underlying mechanisms that may explain the biological plausibility of this association. Moreover, the existing relationship between nutrition in infancy and childhood and later grip strength is not well established in the literature and this study may help in the construction of the body of evidence of studies analyzing the long-term consequences of early nutrition.

This study was aimed at assessing the role of birth weight, intrauterine growth restriction, and nutritional status in childhood on grip strength in young adults from the 1982 Pelotas (Brazil) birth cohort.

## Materials and methods

### *Participants*

In 1982, all maternity hospitals in the city were visited daily and the 5914 live births whose families lived in the urban area of the city were examined and their mothers interviewed. These individuals have been followed often throughout the years [8].

The study was approved by the Ethics Committee of the Medicine School of the Federal University of Pelotas. Written informed consent was obtained during the 2012–2013 follow-up before the interviews and physical evaluations.

### *Infancy and childhood follow-ups*

Maternity hospital staff used pediatric scales (Filizolla, Brazil; precision 10 g) to record birth weight. The scales were calibrated weekly. Gestational age was obtained by asking mothers the date of their last menstrual period. Term birth was defined as gestational age ≥37 wk. Information on prepregnancy weight was referred by the mother and was confirmed on the antenatal care register card. The research team measured maternal height soon after the women were admitted to the maternity hospital in 1982.

In 1984, a census was carried out in the urban area of the city in search of the cohort members; 4934 children were identified, which added to the 227 deaths representing a follow-up rate of 87.2%. Mean age at follow-up was 19.4 mo. In 1986, approximately 84.2% of the cohort children were located. In these visits, children were weighed using a portable spring scale with an accuracy of ±100 g (CMS Weighing Equipment, London, UK) and had their supine length (1984) or standing height (1986) measured using boards manufactured locally according to international specifications (AHRTAG, London, UK).

The weights in childhood were transformed to *z*-scores of weight, as well as the length/height at the 1984 and 1986 follow-ups, for age and sex using the 2006 World Health Organization growth standards [18]. Weight-for-length/height for sex was also transformed to *z*-score according to the same growth standard. Birth weight was transformed to *z*-score according to gestational age, using the reference population developed previously. Small-for-gestational-age was defined as a birth weight below the 10th percentile for gestational age and sex of the Williams' curve [19].

### *Follow-up at 30 y*

From June 2012 to February 2013, the cohort members were invited to visit the Epidemiologic Research Center, and 3701 individuals (follow-up rate: 68.1%, considering 325 known deaths) were examined and interviewed. Standing height was measured to the nearest 1 mm with barefooted participants using a wooden stadiometer. Weight was assessed using a BodPod® scale with a precision of 0.01 kg. Body mass index (BMI) was calculated as weight in kg divided by the square of height in m.

Grip strength was obtained using the Jamar hand dynamometer (Lafayette Instrument Company, Lafayette, IN, USA). The assessment occurred with the

**Table 1**
Characteristics of participants from the 1982 Pelotas (Brazil) birth cohort included in the analysis

| Subjects' characteristics | Males | | Females | |
|---|---|---|---|---|
| | N | % | N | % |
| Maternal schooling (y) | | | | |
| 0–4 | 551 | 31.9 | 557 | 32.1 |
| 5–8 | 755 | 43.6 | 736 | 42.4 |
| 9–11 | 191 | 11.1 | 188 | 10.8 |
| ≥12 | 231 | 13.4 | 256 | 14.7 |
| Maternal smoking during pregnancy | | | | |
| Yes | 597 | 34.5 | 608 | 35 |
| No | 1133 | 65.5 | 1131 | 65 |
| Birth weight (g) | | | | |
| <2500 | 109 | 6.3 | 158 | 9.1 |
| ≥2500 | 1621 | 93.7 | 1581 | 90.9 |
| Skin color | | | | |
| White | 1341 | 75 | 1476 | 77.1 |
| Non-white | 446 | 25 | 438 | 22.9 |
| Economic status at 30 y (ABEP*) | | | | |
| A/B (richest) | 960 | 68.0 | 933 | 63.7 |
| C | 408 | 28.9 | 464 | 31.7 |
| D/E (poorest) | 44 | 3.1 | 67 | 4.6 |
| Nutritional status at 30 y (BMI) | | | | |
| Underweight (<18.5 kg/m$^2$) | 27 | 1.6 | 104 | 5.6 |
| Normal (18.5–24.9 kg/m$^2$) | 625 | 35.6 | 809 | 43.7 |
| Overweight (25–29.9 kg/m$^2$) | 714 | 40.7 | 515 | 27.8 |
| Obese (>30 kg/m$^2$) | 388 | 22.1 | 425 | 22.9 |
| Physical activity ≥150 min/wk | | | | |
| Yes | 1034 | 59.6 | 944 | 50.5 |
| No | 701 | 40.4 | 927 | 49.5 |
| Grip strength (kg) [mean (SD)] | 1730 | 50.2 (8.2) | 1739 | 29.7 (5.4) |
| Lean mass (kg) [mean (SD)] | 1596 | 56.7 (6.6) | 1721 | 38.6 (5.3) |

ABEP, Associação Brasileira de Empresas de Pesquisa; BMI, body mass index
* Criterion based on possession of certain consumer goods, head of the household's schooling, and presence of a maid.