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Samuel L. Buckner
University of South Florida, Tampa

Scott J. Dankel
University of Mississippi

Zachary W. Bell
University of Mississippi

Takashi Abe
University of Mississippi

Jeremy P. Loenneke
University of Mississippi

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The Association of Handgrip Strength and Mortality: What Does It Tell Us and What Can We Do With It?

Samuel L. Buckner,[1] Scott J. Dankel,[2] Zachary W. Bell,[2] Takashi Abe,[2] and Jeremy P. Loenneke[2]

Abstract

The relationship between grip strength and mortality is often used to underscore the importance of resistance exercise in physical activity guidelines. However, grip strength does not appear to appreciably change following traditional resistance training. Thus, grip strength could be considered reflective of strength independent of resistance exercise. If true, grip strength is not necessarily informing us of the importance of resistance exercise as an adult, but potentially highlighting inherent differences between individuals who are stronger at ''baseline'' compared to their weaker counterpart. The purpose of this article is to discuss: (1) potential factors that may influence grip strength and (2) hypothesize strategies that may be able to influence grip strength and ultimately attain a higher baseline level of strength. Although there appears to be a limited ability to augment grip strength as an adult, there may be critical periods during growth/development during which individuals can establish a higher baseline. Establishing a high baseline of strength earlier in life may have long-term implications related to mortality and disease.

Keywords: aging, mortality, strength, grip strength, human baseline, development

Introduction

In past years there has been an increased focus on the importance of including resistance type exercise in the physical activity guidelines. For example, recommendations from the American College of Sports Medicine and the U.S. Departments of Health and Human Services have recommended strength training at least twice a week to improve muscular strength.[1,2] In addition, recent studies have shown that grip strength is associated with several clinically relevant health outcomes and biomarkers.[3–8] Grip strength is commonly used as a proxy measure of overall strength,[9–11] in part, because it is quick, easy to administer, and cost effective. The relationship between grip strength and mortality is often used to underscore the importance of resistance exercise in physical activity guidelines. However, it is mechanistically unclear how mortality might be improved through increasing grip strength.

The human baseline hypothesis suggests that strength prior to, and independent of, resistance exercise may represent the most appropriate biomarker of long-term health outcomes.[12] Herein, we suggest that much of an adult's muscle strength is realized prior to training. In addition, we suggest that interventions may have a limited ability to change what a person is relative to what they are at baseline (will vary depending on the strength measure).[12] The human baseline would represent the value of strength an individual possesses as an adult before resistance training and returns to following detraining. From a clinical perspective, the ''baseline'' is the strength one attempts to regain following an injury (if they were not resistance trained) and the baseline one seeks to maintain (as long as possible) with aging. Interestingly, grip strength does not appear to appreciably change following traditional resistance training.[13] Thus, grip strength could be considered reflective of strength independent of resistance exercise. If true, grip strength is not necessarily informing us of the importance of resistance exercise as an adult, but potentially highlighting inherent differences between individuals who are stronger at baseline compared to their weaker counterparts. If grip strength is not underpinning the importance of resistance training, it is unclear what the relationship between grip strength and mortality actually means. The purpose of the present article is to discuss: (1) potential factors that may influence grip

[1]Division of Exercise Science, USF Muscle Laboratory, University of South Florida, Tampa, Florida.
[2]Kevser Ermin Applied Physiology Laboratory, Department of Health, Exercise Science, and Recreation Management, The University of Mississippi, University, Mississippi.

strength and (2) hypothesize strategies that may be able to influence grip strength and ultimately attain a higher baseline level of strength.

Discussion

Why grip strength?

The relationship between grip strength and mortality has been used to underpin the importance of resistance exercise; however, there is little mechanistic reason to believe that increasing grip strength would decrease mortality. Interestingly, some of the best correlates with grip strength are height,[3,14] body mass,[15] and BMI,[3,14,15] which suggest that being a large person may be the best way to acquire a high level of grip strength. Yet, Rantanen et al.[14] found that grip strength measured during mid-life, in a *healthy* population, predicts mortality in a 30-year follow-up, independent of BMI. Specifically, within all BMI categories, individuals in the lower tertile of grip strength had a 20%–39% increased risk of mortality. This would suggest that the association is not driven solely by body size and that there appears to be a benefit to being inherently stronger within a given BMI classification.

Although the relative composition of the mass (*i.e.*, sarcopenic obesity) is an important consideration, those authors speculated that the mechanisms underlying this association may be attributed to: (1) the influence of early life factors (*i.e.*, nutrition and physical activity); (2) strength being a risk factor for disease or an indicator of subclinical disease; (3) strength being related to muscle mass which acts as a protein reserve during cases of trauma; (4) strength being related to physical activity which is related to mortality; and (5) other genetic (hereditary) contributions. Of those proposed mechanisms, it seems unlikely that physical activity is playing a large role with grip strength. Specifically, there appears little evidence that grip strength undergoes any appreciable change following traditional resistance exercise in adults.[13,16] Furthermore, baseline muscle mass is likely more important than hypertrophy of existing muscles regarding the outcome of grip strength.[17] Meaning, having a larger muscle may be important for grip strength; however, making that muscle larger through compensatory hypertrophy (*i.e.*, resistance training for growth) appears to have little influence on the outcome of strength.[18,19] Thus, of the strategies related to optimizing early life factors (*i.e.*, physical activity and nutrition) both intrauterine and during growth/development may be most important for establishing a high baseline of grip strength. Under this paradigm, the goal would not be the promotion of resistance training as an adult, but using strategies during development to acquire a higher baseline level of strength. Given the great deal of variability observed in grip strength,[20] it seems plausible that strategies involving physical activity and nutrition can be implemented to help achieve a higher baseline value of grip strength.

The variability in grip strength

There is a large amount of variability in grip strength values, even among adults (ages 39–73) with a similar height (*e.g.*, range of 14–32 kg for men 150–154.6 cm in height).[20] Yet, typical resistance training programs do not appear to result in changes in grip strength as measured by a hand dynamometer. For example, Rhodes et al.,[13] found that 52 weeks of full body exercise did not facilitate any changes in grip strength in a group of older women, despite increased bench press, bilateral leg press, and unilateral elbow flexion strength. Similarly, Tieland et al.[16] found that 24 weeks of whole body resistance training increased lower body muscle strength and physical performance without any meaningful change in grip strength ($\sim$2 kg). The authors suggested that handgrip strength does not represent a valid measure to evaluate changes in muscle strength with training.[16] This suggests that the variability in grip strength is not driven by engagement in resistance exercise, but is attributed to other factors. It seems reasonable to suggest that if it is possible to augment ''baseline strength,'' it must be done during development. Sayer et al.[21] demonstrated that a higher birth weight is associated with better grip strength in later life in men and women. Similarly, Kuh et al.[22] examined the relationship between birth weight and adult weight at the age of 53, finding that an extra kilogram of birth weight was associated with a 3.05-kg difference in grip strength for men and a 2.00-kg difference for women. Authors suggest that part of this observation is explained by genetic factors, but also likely due to nutrition during critical periods of development. Gale et al.[3] found that birth weight was a significant predictor of bone mineral content at the lumbar spine, femoral neck, and whole body of men and women in the sixth and seventh decade of life. Most interestingly, these relationships were observed *independent* of known adult lifestyle determinants of bone loss such as physical inactivity, low dietary calcium intake, and cigarette smoking. Authors suggest that ''genetic and/or intrauterine environmental factors that influence the fetal growth trajectory and are reflected in birth weight have long-term consequences on body composition.'' Although there does not appear to be a consensus on the contributions of genomics versus intrauterine environment on birth weight, data examining the birth weight in twins (in a large sample of 2930 pairs) suggest that $\sim$10% of birth weight is attributed to heritability, with a large part of the variability explained by gestational age. In addition, authors noted lower birth weights if there was maternal smoking during pregnancy. Further, animal models have demonstrated that nutrition can influence muscle mass. For example, in large litters of piglets, it has been suggested that intrauterine position can influence nutrition and have subsequent influence on the number of muscle fibers.[23] It seems reasonable to suggest that such intrauterine factors may also contribute to differences observed in ''baseline strength'' (*i.e.*, grip strength). Considering this, strategies to increase birth weight and provide optimal intrauterine nutrition may be of the utmost importance if trying to maximize an individual's baseline strength.

Where can we make a difference?

Studies correlating grip strength and morality appear in position stands promoting resistance exercise. For example, the ACSM position stand for physical activity cites the Gale et al.[3] investigation correlating grip strength with morality in a section titled: ''What are the Benefits of Improving Muscular Fitness.'' Although other studies are cited that correlate more complex strength tasks (*i.e.*, 1RM leg press

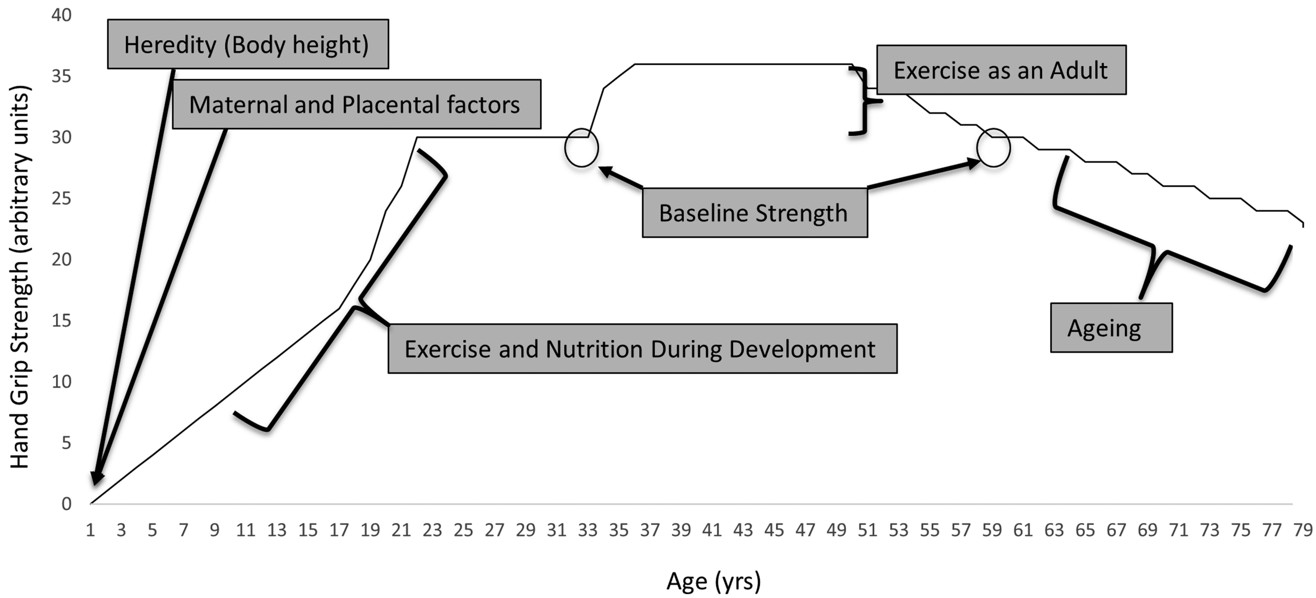

FIG. 1. Factors contributing to the human baseline. Adapted from Buckner et al.[12] This figure displays the human baseline hypothesis. The present example assumes arbitrary units for handgrip strength (*y*-axis) across age in years (*x*-axis). The circles indicate the establishment of ''baseline'' strength. The human baseline hypothesis would suggest that this value has more diagnostic value than increases in strength achieved through exercise as an adult. With aging, an individual attempts to maintain this ''baseline'' as long as possible. However, strength will ultimately decline as an individual advances in age.

and bench press) with mortality, it is still unclear if these associations are linked with behavior. In the case of grip strength, it seems quite unlikely that the association can be used as a justification for resistance exercise behaviors. This is perplexing for health promotion professionals, particularly as it has been suggested that the major environmental correlate of muscle strength during adult life is physical activity.[22] Despite physical activity's ineffectiveness to augment grip strength, there is some evidence to suggest that intrauterine nutrition and maternal behaviors can influence birth weight. In addition, heritability studies suggest that up to 65% of the variance in grip strength is shared by genetics, leaving some scope for environmental factors.[24]

In addition to a focus on intrauterine factors, early childhood development may be an opportune time to influence the baseline level of strength. Undernutrition, particularly during development, can lead to stunting.[25,26] Thus, it is no surprise that proper nutrition during development is important for proper growth. Interestingly, the obesity literature may inform us of another important consideration regarding the developmental years. For example, the majority of adiposity is suggested to be developed during the prenatal, adiposity rebound, and adolescent months/years.[27] The adiposity rebound period is thought to be the period in which behaviors related to food intake acquired in early childhood begin to be expressed. However, this period may also reflect early life undernutrition. This critical time period of fat cell development may also represent a time where muscle can be developed to establish a higher baseline of both size and strength. Regarding adolescents, this time period marks a time of drastic change in body composition.[27] Results from the Framingham Children's Study have suggested that children in the highest tertile of average daily activity from ages 4 to 11 years had smaller gains in BMI, tricep skinfold, and sum of five skinfolds throughout childhood.[28] Applying a similar rational within the context of the human baseline, it seems reasonable to assume that this critical time period may also be important for the development of other biological variables such as grip strength and baseline muscle mass.

Conclusions

Cross-sectional literature has informed us on the importance of high levels of grip strength. Yet, it remains elusive what the practical application of this knowledge actually is. Although there appears to be a limited ability to augment grip strength as an adult, there may be critical periods during growth/development during which individuals can establish a higher baseline. Establishing a high baseline of strength early in life may have long-term implications related to mortality and disease. Figure 1 has been adapted from Buckner et al.[12] and provided to aid in the understanding of the human baseline hypothesis.

Future research

Future studies examining the potential of interventions during fetal development and childhood years may yield more favorable outcomes compared with interventions designed to prevent atrophy and maintain strength with advancing age. With regards to successful aging, particularly as it related to the prevention muscle mass and strength loss, there is a great deal of focus on preventing these age associated losses through both resistance exercise[29,30] and nutrition.[31,32] However, based on our interpretation of the cross-sectional literature combined with knowledge on biomarkers of health (such as grip strength), it seems that there may be an opportunity to have additional influence through early life intervention. Such interventions may include a focus on intrauterine factors, early childhood development, and the influence of physical activity during early school years. Ethical considerations make this investigation difficult with respect to traditional randomized controlled trials (*i.e.*, denying children the extra exposure to physical activity and nutrition that may influence mortality), but there are potentially other ways to determine the efficacy of this idea. One starting point may be longitudinal studies examining the effect that changes in early life physical activity and/or nutrition have on changes in grip strength, mortality, and other biomarkers of health status. If grip strength increases in response to these interventions but does not favorably impact mortality or other health outcomes, the human baseline hypothesis would need to be revised or abandoned. However, if these early life interventions produced changes in grip strength which were favorably associated with mortality/health into later adulthood, then this would provide evidence for the hypothesis that there may be critical periods during growth/development where health professionals can effect change for successful aging.

Author Disclosure Statement

No competing financial interests exist.

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Address correspondence to:
Jeremy P. Loenneke
Kevser Ermin Applied Physiology Laboratory
Department of Health, Exercise
Science, and Recreation Management
The University of Mississippi
231 Turner Center
University, MS 38677

E-mail: jploenne@olemiss.edu

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