

Type 2 Diabetes, Muscle Strength, and Impaired Physical Function

The tip of the iceberg?

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There is growing recognition that the complications associated with type 2 diabetes may translate into functional impairment in older people (1). This may reflect a link between the metabolic and mechanical functions of muscle. However, the possibility that the link between glucose tolerance and physical function extends to people without diabetes has not been previously considered. The objective of this study was to determine whether there is a relationship among glucose tolerance, muscle strength, and physical function in men and women with and without type 2 diabetes.

RESEARCH DESIGN AND METHODS

A cross-sectional survey within a cohort study design was used. Information was obtained on self-reported diabetes status cross-checked with medication data, glucose, and insulin levels 2 h after an oral glucose tolerance test (for participants without a previous diagnosis of diabetes) (2), grip strength using a Jamar dynamometer (3), and physical function using the physical function component of the Medical Outcomes Study 36-item short form questionnaire. This is a measure of subjective health status widely validated in both men and women (4,5).

The population-based study sample consisted of 1,391 men and women aged between 60 and 70 years and living in the English county of Hertfordshire. Additional information was collected on medical and social history, physical activity,

height, and weight. The study had ethical approval from the North and East Hertfordshire Local Research Ethics Committee, and all subjects gave written informed consent. The methods for the cohort study have been described previously (6). Descriptive statistics, ANOVA, and linear and logistic regression were used to analyze the data with the Stata 8.0 statistical package.

RESULTS— Known diabetes status was associated with significantly lower grip strength, particularly in the men. Mean grip strength in diabetic men was 41.8 kg compared with 44.1 kg in men with impaired glucose tolerance (IGT) and 44.7 kg in men with normal glucose tolerance ($P = 0.002$). An SD increase in glucose concentration was associated with a significant reduction in grip strength after adjustment for weight ($\beta -0.97$ kg, $P < 0.001$) or weight and height ($\beta -0.60$ kg, $P = 0.02$), and a significant relationship remained when newly diagnosed diabetic men were excluded. There were similar trends when those with IGT were also excluded (Fig. 1). There was no consistent pattern of relationships between fasting insulin concentration and grip strength.

People were classified as having poor physical function if they were in the lowest sex-specific fifth of the distribution. Diabetic status, IGT, and higher glucose levels with normal glucose tolerance were associated with higher odds of poor physical function in the men. The crude odds

ratio (OR) for poor physical function in diabetic men compared with those with normal glucose tolerance was 2.73 ($P < 0.001$) and in those with IGT compared with those with normal glucose tolerance 1.62 ($P = 0.03$). The crude OR for having poor physical function per SD increase in 2-h glucose was 1.39 ($P < 0.001$); this increased to 1.57 ($P = 0.001$) after excluding newly diagnosed diabetic men and to 1.65 ($P = 0.01$) after also excluding those with IGT, suggesting higher susceptibility to the adverse effects of higher glucose levels on physical function in those with normal glucose tolerance. These relationships were robust to adjustment for weight and height. Generally the relationships in the women showed similar patterns but were weaker and did not consistently reach statistical significance.

CONCLUSIONS— We have demonstrated that known and newly diagnosed diabetic older men have significantly weaker muscle strength and higher odds of impaired physical function than those without diabetes. This is consistent with findings from previous studies. However, we have also shown for the first time that the relationship between raised glucose levels, weaker muscle strength, and impaired physical function includes those with IGT and also extends across the normal range of glucose concentration. The effect sizes in the women were smaller and less consistent and may reflect sex differences in body composition.

Lower levels of physical activity could explain the relationship between increased glucose level and reduced grip strength. However, the findings remained significant after adjustment for level of physical activity, suggesting that this was not the full explanation. We suggest that the observed associations may be causal. However, the study is cross-sectional, so the direction of the associations needs consideration. Weaker muscles tend to be smaller and therefore have potential for reduced glucose uptake and hyperglycemia. For example, transporter protein GLUT4 expression at the plasma mem-

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Received for publication 11 March 2005 and accepted in revised form 27 June 2005.

Abbreviations: IGT, impaired glucose tolerance.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

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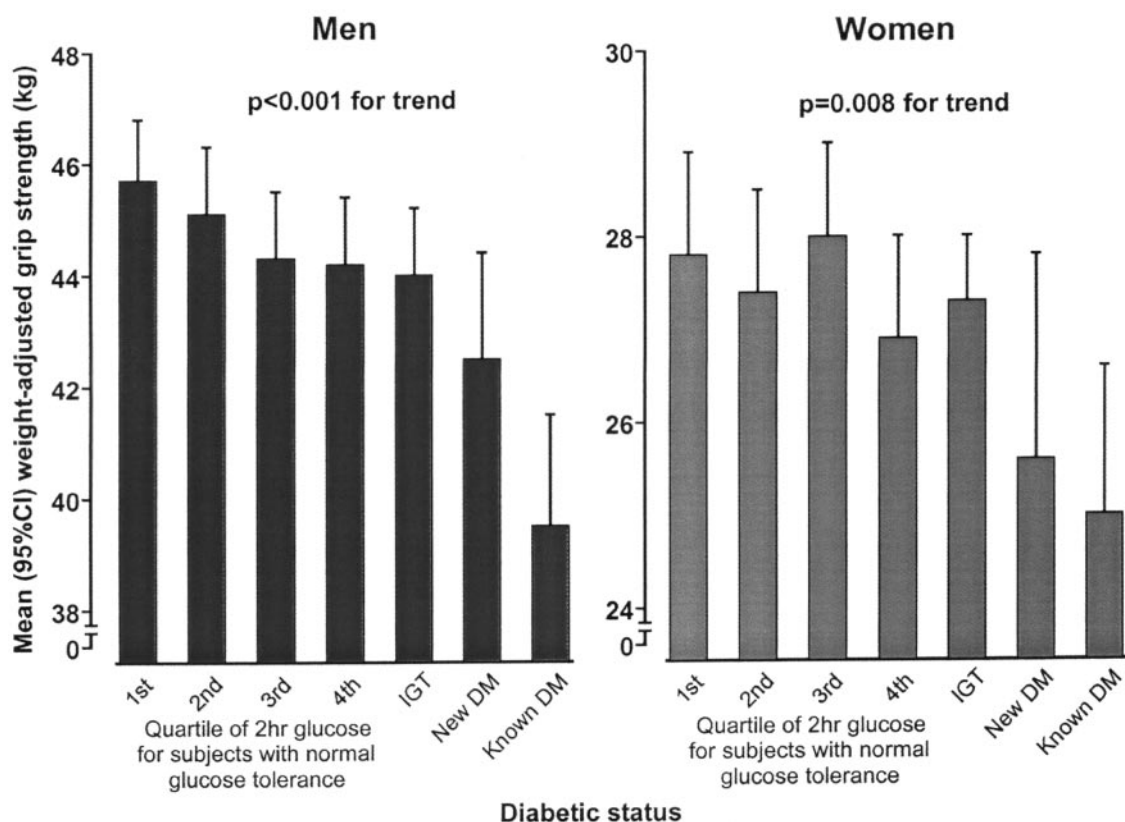


Figure 1—Relationship between weight-adjusted grip strength and diabetes status in men and women.

brane is related to fiber volume in human skeletal muscle fibers (7).

However, previous work suggests that glucose disposal is not directly associated with muscle mass (8), and our findings were robust to size adjustment. Furthermore, there is clinical evidence that the causal association lies in the opposite direction. For example, there is a temporal relationship between the diagnosis of diabetes and the subsequent development of muscle weakness associated with complications such as diabetic amyotrophy. This is consistent with raised glucose levels leading to reduced strength and impaired physical function, and in vitro and in vivo animal models provide evidence that hyperglycemia can affect contractile function and force generation in muscle (9).

Our findings suggest a graded association between increased glucose level, weaker muscle strength, and impaired physical function not only in older men with diabetes or IGT, but also in those without either diagnosis. The relationships in women were less clear. This work

warrants replication because there are implications for considering population-based strategies to reduce glucose across the whole range in later life to improve physical function for older people.

Acknowledgments—The Medical Research Council and the University of Southampton provided funding for this study.

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