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ORIGINAL ARTICLE

Nutritional status and self-reported and performance-based evaluation of physical function of elderly persons in rural Bangladesh

TAMANNA FERDOUS¹, TOMMY CEDERHOLM¹, ABDUR RAZZAQUE²,
ÅKE WAHLIN³ & ZARINA NAHAR KABIR⁴

¹Clinical Nutrition and Metabolism, Department of Public Health and Caring Sciences, Uppsala University, Uppsala, Sweden, ²icddr,b: Knowledge for Global Lifesaving Solutions, Dhaka, Bangladesh, ³Department of Psychology, Stockholm University, Stockholm, Sweden, and ⁴Division of Nursing, NVS, Karolinska Institute, Stockholm and Social Development Programme, BRAC, Dhaka, Bangladesh

Abstract

Aim: To investigate the impact of nutritional status on self-reported as well as performance-based indicators of physical function in a rural elderly population in Bangladesh. **Methods:** A cross-sectional study conducted in Matlab, Bangladesh, included 457 randomly selected community-living elderly persons aged 60 years or more (60–92 years; 69 ± 7 years). Mobility, activities of daily living (ADL), performance tests, handgrip strength, the Mini Nutritional Assessment (MNA) and a structured questionnaire were used to assess physical function, nutritional status, socioeconomic status and health status, respectively. Descriptive and linear hierarchical regression analyses were applied. **Results:** Seven per cent of the participants reported limitations in mobility, and 8% reported limitations in ADL. However, more than half of the participants had difficulties in performing one or more items in the performance tests. According to the MNA, 26% of the participants were undernourished and 62% were at risk of malnutrition. More undernourished participants than well-nourished participants reported limited mobility, impaired ADL and difficulties in the performance tests. A corresponding reduction in grip strength was observed in the undernourished group. Accordingly, higher MNA scores, indicating better nutritional status, were significantly associated with higher mobility index, higher ADL index, higher performance tests index, and higher scores in handgrip strength. These associations remained after adjusting for demographic, socioeconomic and health status differences. **Conclusions:** Good nutritional status is important for the physical function of elderly people, even after controlling for possible confounders. Performance tests indicated a higher degree of functional impairment than that observed by self-reported estimation.

Key Words: Activities of daily living, Bangladesh, elderly, nutritional status, performance tests, physical function

Introduction

A major concern regarding increased life expectancy, particularly in low-income countries [1], is the rise in morbidity and related decline in functional ability, both physical and cognitive, among elderly persons. Physical function, the main focus of this article, is a complex and extensive area that can refer to the function of a specific organ or organ system, mobility, strength, or the ability to carry out everyday activities [2]. Because of its different dimensions, physical function is measured by various instruments. Most

studies assess physical function using either performance-based [3,4] or self-reported measures [5,6], the former addressing impairment (physical capacities, e.g. balance, sensory abilities, and range of motion) and the latter disability (e.g. gross body movements and self-care) [7]. The two types of assessment are rarely used concomitantly in the same study.

The World Health Organization (WHO) defines impairment as “problems in body function or structure such as a significant deviation or loss” [8]. Disability is described by the WHO as a complex

Correspondence: Tamanna Ferdous, Clinical Nutrition and Metabolism, Department of Public Health and Caring Sciences, Uppsala University, Uppsala Science Park, 751 85 Uppsala, Sweden. Tel: +46 18 611 79 67. Fax: +46 18 611 79 76. E-mail: tamanna.ferdous@pubcare.uu.se

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phenomenon, reflecting an interaction between a person's health conditions and the social and environmental context in which he or she lives. Although disability serves as an umbrella term for impairments, restrictions in activities, or limited participation, impairment may not always necessarily lead to disability [8]. Impairment can be improved during a rehabilitation process [2].

Functional limitation during the process of ageing is a result of impairments caused by a number of pathological conditions and chronic diseases [9]. Poor diet is one of the factors linked to chronic diseases [10]. Persons with impaired function may have difficulties in carrying out activities of everyday life [11]. Such difficulties can affect family life, social relationships, psychological well-being, and level of independence [12]. In the context of a low-income country, e.g. Bangladesh, persons with functional difficulties are often valued negatively by the society [13].

Undernutrition among older people is another significant public health problem all over the world [14]. Nutritional frailty refers to the limitations in physical function that may occur in old age due to unintentional weight loss and/or sarcopenia, i.e. loss of muscle mass and strength [15]. Although age-related decline in muscle strength is a gradual process, this may occur earlier in malnourished persons than in well-nourished persons [16]. Reduced muscle strength is, in turn, found to be strongly associated with poor mobility [17]. Some studies report that poor nutritional status is associated with reduced functional status [4], and others note that functionally dependent elderly participants have worse nutritional status than functionally independent persons [18].

The contributions of elderly persons to their families are significant in Bangladesh. They provide practical support in household tasks by engaging in the supervision of the domestic work. Many contribute financially as main or complementary earners of the household [19]. Thus, being functionally active is important for the elderly themselves, and also has a positive impact on their families. To the best of our knowledge, there are few reports, if any, of nutritional effects on functional ability in elderly people in low-income countries such as Bangladesh.

The aim of this study was to investigate the impact of nutritional status on functional ability observed as physical function, and assessed by performance-based as well as by self-reported measures in an elderly population in a rural area of Bangladesh. Other potential predictors, such as demographic, socioeconomic and health status, were also considered.

Material and methods

Participants

This cross-sectional study of elderly persons aged 60+ years was conducted during August 2003 to January 2004 in Matlab, a rural area 55 km south-east of Dhaka city in Bangladesh. A Demographic Surveillance System (DSS) of >200,000 inhabitants has been maintained by icddr,b: Knowledge for Global Lifesaving Solutions, Dhaka, Bangladesh (formerly known as the International Centre for Diarrhoeal Disease Research, Bangladesh) in this area since 1966. From a randomly selected sample of 850 elderly (60+ years) individuals from the DSS database, 625 participated in the home interviews, of whom 473 underwent clinical examination. This study reports results on 457 individuals for whom complete data on all relevant variables were available. The non-respondents in the clinical examination ($n=152$) were mainly women, were older, and had poorer socioeconomic status, but their health status was similar to that of the respondents of the present study. The study was approved by the ethics committees at icddr,b and Karolinska Institutet, Stockholm.

Nutritional assessment

The Mini Nutritional Assessment (MNA) [20], an instrument specially designed for assessing the nutritional status of elderly persons, was used. The MNA comprises 18 questions regarding anthropometry, global assessment, dietary assessments, and a subjective assessment. As the MNA has been mostly used for elderly people in high-income countries, some of the items in the MNA are not relevant for a low-income setting; for example, nursing homes for sick elderly people do not exist in Bangladesh. In addition, we used the cut-off for body mass index suggested by the WHO. Information on calf circumference was also lacking. As a result, a modified version [21] of the MNA was used in this study. The maximum score is 28, with a higher score indicating better nutritional status. A score <15 indicates undernutrition, a score between 15 and 21.5 indicates at risk of malnutrition, and a score ≥ 22 indicates no nutritional problem.

Measures of physical function

Four different measures were used. Two were based on self-report, i.e. mobility and activities of daily living (ADL), and two were based on performance, i.e. a combination of various performance tests, and handgrip strength. Information about mobility, ADL and performance tests was collected during

home interviews. Handgrip strength was assessed during clinical examinations.

Information on mobility included questions about ability to walk indoors, to walk outdoors, and to stand up without any help. Each mobility question had four alternative responses: "yes, without any problem"; "yes, with help of sticks"; "yes, with help of someone"; and "bedridden". In the analyses, the three last alternatives were classified as indicating limitations in mobility. A mobility index (0–3 points) was constructed on the basis of the responses to the three questions about abilities, where higher scores indicated better mobility.

In the current study, ADL measures dependency in personal care according to five items: ability to get in and out of bed, ability to use the toilet, ability to take a bath, ability to eat, and ability to dress. Each of the ADL questions had three response alternatives: "yes"; "yes, but need help"; and "no". Participants who reported dependence in any of the five tasks were classified as having limitations in ADL. Furthermore, an ADL index (0–5 points) was constructed on the basis of the responses to the five questions, where higher scores indicated better function.

The performance tests comprised six items and covered several dimensions of physical function, such as range of motion, ability to grasp, fine motor skills, strength, balance, and flexibility. Participants were asked to pick up a pen from the floor, lift a 1-kg packet of salt, move their wrist, touch their opposite earlobes (e.g. left earlobe with right hand, with arm behind the head), and get up from the bed without using their hands. After each task, the interviewers recorded whether the participants could perform the task easily, could perform it with difficulty, or could not perform at all. If a participant could not perform a task easily, he or she was identified as having performance limitations. A performance test index (0–6 points) was constructed on the basis of performance of the six tasks, higher scores indicating better performance.

Handgrip strength of the participants was measured in kilograms, using a handgrip dynamometer (DynEx[®], USA). The grip measurements were performed with the participants in a sitting position, with both hands being measured alternately three times. The best score was used.

Background information

Demographic indicators included age, sex, and marital status. Age was used as a continuous variable. Information on marital status was coded as married or single.

Socioeconomic status indicators included monthly income and literacy. Income was coded as having no

income or having an income. Literacy was dichotomized into illiterate and literate.

Health status was indicated by comorbidity defined as having more than one self-reported health problem, e.g. respiratory problem, stomach problem, sensory problem, or pain [21].

Statistical analyses

Descriptive analyses were performed, and chi-square and independent *t*-tests were used to examine differences according to nutritional status, and for men and women separately when appropriate. Hierarchical linear regression analyses were conducted to determine the impact of demographic, socioeconomic, health and nutritional status on all four indicators of physical function. All analyses were conducted in a stepwise fashion, where the demographic information were entered in the first step, socioeconomic status in the second step, and self-reported health problems in the third step. Finally, nutritional status, i.e., MNA scores, was entered, followed by, step by step, the interaction terms age $\times$ MNA, sex $\times$ MNA, and health problems $\times$ MNA. Indices of mobility, ADL and performance tests and grip strength values were used as dependent variables in these analyses. The analyses were performed using the software SPSS (15.0) for Windows.

Results

Table I presents information on demographic, socioeconomic, health and nutritional status of the study participants. As shown in Table II, 7% of the participants reported limitations in mobility, mainly outdoor mobility, and 8% reported limitations in ADL, where toileting and bathing were the most frequently reported limitations (data not shown). In contrast, difficulties in any of the performance tests were observed in more than half of the participants. Significantly more women than men had difficulties in performing most of the tasks, but no significant gender difference was observed in the self-reported data (data not shown). In all cases, significantly higher percentages of the undernourished participants reported impairments as compared with both well-nourished participants and participants who were at risk of malnutrition. Mean handgrip strength was significantly lower in the undernourished group than in those at risk and the well-nourished. Women were more vulnerable than men in all the groups.

Table III presents results of the hierarchical linear regression analyses with main and interaction effects.

The results indicated that increasing age and poor nutritional status were significantly associated with limitations in mobility and ADL. Among the interaction terms, none but the age $\times$ MNA interaction term showed a significant association with mobility and ADL. The effect resulted from the

negative effect of nutritional status being more pronounced in the oldest age range. Self-reported health problems did not show any significant association with either mobility or ADL.

Finally, increasing age, being a woman, health problems and poor nutritional status were significantly associated with limitations in performance tests and low grip strength. The socioeconomic indicators did not show any significant association with any of the dependent measures.

Table I. Demographic, socioeconomic, health and nutritional profile of the study participants ($N=457$).

	Total (%)
Age (years, mean $\pm$ SD)	69.5 $\pm$ 7
Sex	
Men	208 (45)
Women	249 (55)
Marital status	
Married	267 (58)
Single	190 (42)
Socioeconomic status	
Has income	163 (36)
Literate ^a	174 (39)
Self reported comorbidity ^b	
0–1 disease	17 (4)
2–5 diseases	152 (33)
>5 diseases	285 (63)
Median (25th and 75th quartiles)	6 (5 and 8)
Nutritional status according to MNA	
Undernourished	118 (26)
At risk of malnutrition	282 (62)
Well nourished	57 (12)

SD, standard deviation; MNA, Mini Nutritional Assessment.

^aData missing for five individuals.

^bData missing for three individuals. For classification of self-reported health problems, see [21].

Discussion

This study examined the impact of nutritional status on physical function in elderly persons living in rural Bangladesh. Other potential predictors, i.e. demographic, socioeconomic and health status, were also considered in the multiple regression models. The findings showed that increasing age and poor nutritional status were significantly associated with limitations in physical function however they were assessed, whether self-reported or performance-based. Being a woman and having multiple health problems were associated with limitations in physical function as assessed by performance measures and grip strength, but not as assessed by self-reported ADL or mobility. The negative effect of nutritional status on self-reported physical function was more pronounced in the oldest age range.

Table II. Limitations in physical function of elderly participants according to their nutritional status ($N=457$).

	Mini Nutritional Assessment (MNA)				<i>p</i> -value*		
	Undernourished	At risk of malnutrition	Well-nourished	Total (%)	Undernourished vs. at risk of malnutrition	Undernourished vs. well-nourished	At risk of malnutrition vs. well-nourished
Limitations in mobility ^a (%)	14	5	4	7	0.005	0.040	NS
Limitations in ADL ^b (%)	15	5	5	8	0.001	0.043	NS
Limitations in performance tests ^{c,d} (%)	71	53	36	56	0.001	<0.001	0.032
Handgrip strength (kg) (mean $\pm$ SD)							
Men	23.9 $\pm$ 4	27.1 $\pm$ 7	30.3 $\pm$ 11		0.004	0.001	0.034
Women	13.8 $\pm$ 4	16.3 $\pm$ 6	16.6 $\pm$ 4		0.002	0.003	NS
<i>p</i> -value (difference between sexes)	<0.001	<0.001	<0.001				

ADL, self-reported activities of daily living; SD, standard deviation; NS, not significant. **p*-value obtained from chi-square tests.

^aParticipants who reported needing help to walk indoors, walk outdoors and/or stand up were classified as having limitations in mobility.

^bParticipants who reported needing help to get in and out of bed, use the toilet, take a bath, eat and/or dress were considered to have a limitation in ADL. ^cThe performance tests comprised six tasks. Participants who could not perform any of the tasks easily were identified as having performance limitations. ^dData missing for seven individuals.

Functional assessment identifies an individual's areas of difficulty [22]. However, these difficulties may depend on the individual's lifestyle or the surrounding environment. For example, going to the toilet and taking a bath were the most frequently reported ADL limitations in the current study. To understand these findings, it is necessary to consider the physical environment of Bangladesh, where toilets in the rural areas are mostly built outside the main house and indoor running water is rarely available. People go to a nearby pond to take a bath, or water is carried to them [23].

Comorbidity and poor self-reported health are reported as risk factors for functional limitations [24], as observed in our results. Although morbidity is known to exert a negative impact on function [3], this was not observed in the self-reported items of physical function in the current study. Despite the high prevalence of comorbidity, self-reported limitations in physical function were low as compared to those indicated by performance-based measures. Also, the regression analyses showed a stronger effect of comorbidity on performance-based assessments than on the self-reported assessments. A possible explanation is that some individuals may adjust their living situation to perform certain ADL tasks while others may force themselves to manage the tasks despite their health problems.

The lack of association between gender and self-reported measures in this study was notable, whereas a clear gender association was observed in the performance-based indicators of physical function. Research indicates that women are more likely than men to identify arthritis and osteoporosis as the primary causes of difficulties in performing certain tasks [25]. Osteoporotic fractures are related to lower peak bone mass in women [26]. Among our participants, more women than men reported joint and back pain (data not shown), which might explain the observed gender differences in the performance-tests. Regarding grip strength, the differences were expected, as men have stronger muscles and more muscle mass than women. Conversely, an explanation for the lack of gender differences in self-reported assessment might be that women acknowledged their health problems less than men. Research from Bangladesh confirms that among those suffering from diseases, women use healthcare services less than men do [27].

Our findings indicated that good nutritional status was important for elderly individuals to be functionally active, corresponding with findings reported from other community-living elderly persons [24] and older Rwandan refugees [4]. Even after controlling for all available predictors, nutritional status was significantly associated with all four measures of physical function. In a previous study, we found that

Table III. Results from hierarchical linear regression analyses with demographic, socioeconomic, health and nutritional status as predictors of physical function ($N = 457$).

Predictor	Self-reported measures of physical function						Performance-based measures of physical function					
	Mobility			ADL			Performance tests			Handgrip strength		
	β	p	R^2 change	β	p	R^2 change	β	p	R^2 change	β	p	R^2 change
Demographic factors												
Age (years)	-0.248	<0.001		-0.201	<0.001		-0.186	<0.001		-0.120	0.002	
Women vs. men	-0.037	0.539		0.012	0.848		-0.256	<0.001		-0.640	<0.001	
Single vs. married	-0.053	0.405	0.075	-0.062	0.335	0.050	-0.104	0.086	0.156	-0.016	0.748	0.439
Socioeconomic status												
Income vs. no income	0.009	0.872		0.004	0.950		-0.023	0.674		0.059	0.180	
Literate vs. illiterate	0.007	0.890	0.000	0.019	0.711	0.000	0.066	0.168	0.004	0.068	0.079	0.007
Number of self-reported health problems	-0.071	0.135	0.005	-0.048	0.318	0.002	-0.268	<0.001	0.066	-0.076	0.040	0.005
Nutritional status												
Total MNA score	0.175	<0.001	0.026	0.149	0.003	0.019	0.130	0.004	0.014	0.153	<0.001	0.020
Interaction: Age $\times$ MNA	1.397	0.005	0.016	1.110	0.028	0.010	0.858	0.063	0.006	-0.512	0.179	0.002
Interaction: Sex $\times$ MNA	0.240	0.359	0.002	0.394	0.139	0.005	0.090	0.711	0.000	-0.223	0.269	0.001
Interaction: Number of health problems $\times$ MNA	-0.227	0.345	0.002	-0.139	0.571	0.001	0.132	0.556	0.001	-0.098	0.601	0.000
Total R^2			0.116			0.087			0.247			0.474

ADL, activities of daily living; MNA, Mini Nutritional Assessment.

increasing age, being a woman and self-reported health problems were all associated with poor nutritional status [21]. In the current study, these factors were found to be significantly associated with limitations in physical function. It is of interest to understand whether nutritional status has a direct effect on physical function across age, gender, and health status. The regression analyses indicated that after eliminating the confounding effects of age, gender, and socioeconomic status, and the potentially mediating effect of health status, nutritional status still showed an independent effect on physical function. In addition, the interaction showed that the effect of nutritional status on self-reported physical function was more pronounced among the oldest participants. The lack of corresponding effects of age by MNA scores on performance-based functions, on the other hand, might be explained from the perspective of nutritional effects on the psychological state. On the basis of findings that malnutrition may induce depression [28], we speculate that the malnourished individuals underestimated their actual capacity.

Cachexia, i.e. the severe reduction of protein and energy stores due to disease-triggered catabolism, is often associated with anorexia [29]. Cachexia and anorexia result in loss of muscle mass, i.e. sarcopenia [29], and ensuing limitations in physical function. These might explain the associations between higher number of health problems and limitations in performance tests and poor grip strength found in our study. Starvation may also add to sarcopenia [29]. This scenario is not common in high-income countries, while in many low-income countries poor nutritional status is often associated with poverty [30], which prevents the individual from obtaining sufficient nutrition.

In order to address the multiple dimensions of physical function [2], we assessed four different measures – mobility, ADL, performance tests, and handgrip strength. The first two were self-reported and the latter two were performance-based measurements, from very basic (mobility, ADL) to more specific and complex functions (performance tests). A substantial gap between the prevalence of functional limitations detected by performance-based measurements and self-reported measures is not surprising. Mobility covers very few but essential activities, and these are less complex. In comparison to mobility, ADL covers a relatively wider range of activities, and the items reflect dependency to a certain extent. The performance measures in this study, on the other hand, are rather complex, and information can be obtained only by direct participation. Self-reported information on physical function

is obtained by asking the participants to judge their own capacity to perform a certain task, rather than to report their actual performance [22]. The former can be influenced by language perception, self-interpretation, gender, and social and cultural roles, and may not add any more appropriate information about an individual's physical capacity [31] than that obtained by performance-based measures of physical function.

Some limitations of our study must be acknowledged. With the use of cross-sectional data, only theoretical associations among the variables could be observed. Longitudinal data are needed to provide more detailed information about the magnitude of the impact of nutritional status on physical function as well as directions of causality. Also, the study was conducted in a specific rural area, Matlab. While there is homogeneity to some extent in rural Bangladesh in terms of living conditions, distribution of socioeconomic levels, availability of healthcare facilities etc., there is diversity among the urban population in these respects [23]. Hence, our results may have implications for rural Bangladesh, but not necessarily so for the urban areas.

Analyses of the non-respondents indicated that they were older, had lower socioeconomic status, and were more likely to be women [21]. The exact extent to which the exclusion of these persons from the analyses may have affected the associations of MNA scores with physical ability is unknown. However, a reasonable interpretation is that had we had the clinical data, and thus included more persons with low MNA scores, we would have detected even stronger associations. Thus, we believe that our results were likely to underestimate the true effects of MNA on physical function. Additionally, the current study only examined the consequences of nutritional status on physical function. Another important area of function, i.e. cognition, was not included in this study. This issue needs to be addressed in future studies.

Conclusions

Good nutritional status was important for older people to maintain good physical function. The negative effect of nutritional status on physical function was more evident in the oldest individuals. In addition, the high prevalence of impairment that was revealed by the performance-based measures had not yet translated into disability, as reflected by the relatively low prevalence of limitations in the self-reported measures.

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References

- [1] Kinsella K, Phillips DR. Global aging: the challenge of success. *Popul Bull* 2005;60:1–42.
- [2] Parker MG. Functional limitations among the oldest old. Dissertation. Uppsala: Uppsala University; 1994.
- [3] Gale CR, Martyn CN, Cooper C, Sayer AA. Grip strength, body composition, and mortality. *Int J Epidemiol* 2007;36:228–35.
- [4] Pieterse S, Manandhar M, Ismail S. The association between nutritional status and handgrip strength in older Rwandan refugees. *Eur J Clin Nutr* 2002;56:933–9.
- [5] Kikafunda JK, Lukwago FB. Nutritional status and functional ability of the elderly aged 60 to 90 years in the Mpigi district of rural Uganda. *Nutrition* 2005;21:59–66.
- [6] von Strauss E, Agüero-Torres H, Kåreholt I, Winblad B, Fratiglioni L. Women are more disabled in basic activities of daily living than men only in very advanced ages: a study on disability, morbidity, and mortality from the Kungsholmen Project. *J Clin Epidemiol* 2003;56:669–77.
- [7] McDowell I, Newell C. Measuring health: a guide to rating scales and questionnaires. New York: Oxford University Press, 1996.
- [8] World Health Organization. ICF International Classification of Functioning, Disability and Health. Geneva: WHO, 2001.
- [9] Abrass IB. The biology and physiology of aging. *West J Med* 1990;153:641–5.
- [10] Zohoori N. Nutrition and healthy functioning in the developing world. *J Nutr* 2001;131:2429S–32S.
- [11] Verbrugge LM, Jette AM. The disablement process. *Soc Sci Med* 1994;34:1–14.
- [12] Barbotte E, Guillemin F, Chau N. Prevalence of impairments, disabilities, handicaps and quality of life in the general population: a review of recent literature. *Bull World Health Organ* 2001;79:1047–55.
- [13] Hosain GMM, Atkinson D, Underwood P. Impact of disability on quality of life of rural disabled people in Bangladesh. *J Health Popul Nutr* 2002;20:297–305.
- [14] Visvanathan R. Under-nutrition in older people: a serious and growing global problem. *J Postgrad Med* 2003;49:352–60.
- [15] Bales CW, Ritchie CS. Sarcopenia, weight loss, and nutritional frailty in the elderly. *Annu Rev Nutr* 2002;22:309–23.
- [16] Manandhar MC. Functional ability and nutritional status of free-living elderly people. *Proc Nutr Soc* 1995;54:677–91.
- [17] Lauretani F, Russo CR, Bandinelli S, Bartali B, Cavazzini C, Iorio AD, et al. Age-associated changes in skeletal muscles and their effect on mobility: an operational diagnosis of sarcopenia. *J Appl Physiol* 2003;95:1851–60.
- [18] Huang Y-C, Wueng S-L, Ou C-C, Cheng C-H, Su K-H. Nutritional status of functionally dependent and nonfunctionally dependent elderly in Taiwan. *J Am Coll Nutr* 2001;20:135–42.
- [19] Kabir ZN. The emerging elderly population in Bangladesh: aspects of their health and social situation. Dissertation. Stockholm: Karolinska Institutet; 2001.
- [20] Guigoz Y, Vellas B, Garry PJ. Mini Nutritional Assessment: a practical tool for grading the nutritional state of elderly patients. *Facts Res Gerontol* 1994;2:15–81.
- [21] Kabir ZN, Ferdous T, Cederholm T, Khanam MA, Streathfield K, Wahlin Å. Mini Nutritional Assessment of rural elderly people in Bangladesh. *Public Health Nutr* 2006;9:968–74.
- [22] Brance LG, Meyers AR. Assessing physical function in the elderly. *Clin Geriatr Med* 1987;3:29–51.
- [23] Kabir ZN, Parker MG, Szebehely M, Tishelman C. Influence of socio-cultural and structural factors on functional ability: the case of elderly people in Bangladesh. *J Aging Health* 2001;13:355–78.
- [24] Stuck AE, Walthert JM, Nikolaus T, Büla CJ, Hohmann C, Beck JC. Risk factors for functional status decline in community-living elderly people: a systematic literature review. *Soc Sci Med* 1999;48:445–69.
- [25] Ettinger Jr WH, Fried LP, Harris T, Shemanski L, Schulz R, Robbins J. Self-reported causes of physical disability in older people: the Cardiovascular Health Study. *J Am Geriatr Soc* 1994;42:1035–44.
- [26] LaCroix AZ, Newton KM, Leveille SG, Wallace J. Healthy aging: a women's issue. *West J Med* 1997;167:220–32.
- [27] Ahmed SM, Adams AM, Chowdhury M, Bhuiya A. Gender, socioeconomic development and health-seeking behaviour in Bangladesh. *Soc Sci Med* 2000;51:361–71.
- [28] Cabrera MAS, Mesas AE, Garcia ARL, de Andrade SM. Malnutrition and depression among community-dwelling elderly people. *J Am Med Dir Assoc* 2007;8:582–4.
- [29] Thomas DR. Loss of skeletal muscle mass in aging: examining the relationship of starvation, sarcopenia and cachexia. *Clin Nutr* 2007;26:389–99.
- [30] Pryer J, Rogers S. Epidemiology of undernutrition in adults in Dhaka slum households, Bangladesh. *Eur J Clin Nutr* 2006;60:815–22.
- [31] Guralnik JM, Branch LG, Cummings SR, Curb JD. Physical performance measures in aging research. *J Gerontol* 1989;44:M141–6.