

The University of Tampere

Tampere School of Public Health

**The association between physical capacity and physical strain among
workers in a food factory**

Malkiory Matiya

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University of Tampere

Faculty of Medicine, Tampere School of Public Health

Malkiory Matiya: The association between physical capacity and physical strain among workers in a food factory

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Supervisor: Professor Clas-Hakan Nygård

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ABSTRACT

There has been an increasing trend of involvement in blue-collar tasks among industrial workers in developed countries. This prevailing situation of increasing trend has resulted into rather stable or steady increase in the intensity of physical strain among industrial workers in developed countries. In order to address this problem, the associations between physical capacity and physical strain in regard to work demands and tasks ought to be studied.

Objective: The major purpose of this study was to investigate the relationship between physical capacity and physical strain among workers in a food factory. In addition, the study also examined the association between physical capacity, physical strain and work ability.

Subjects/methods: The study involved 873 food factory workers (females, n= 604, males, n= 269) aged 19-65 years. The sample mean age was 40.5 and it composed of blue-collar workers (n =603), managers (n=85) and white-collar workers (n =182). The data was obtained by administering a cross-sectional survey questionnaire to the subjects.

Results: Physical strain was inversely related to physical capacity. That is to say that the greater the physical capacity the lower the intensity of physical strain and vice versa. There was a substantial gender difference in the intensity of physical strain. Female subjects had higher intensity of physical strain than their male counterparts. Blue-collar workers had poor physical capacity as well as higher intensity of physical strain in comparison with white-collar workers and the managers. Poor health condition and low work ability scores were revealed among those workers with greater intensity of physical strain.

Conclusion: Physical capacity should be considered indispensable for the sake of better health and work ability among food factory workers as having poor physical capacity was greatly associated with higher intensity of physical strain.

Key words: Physical capacity, physical strain, work ability, maximal oxygen consumption, work load, work task, work demands, blue-collar task, white-collar task, manual work.

1. INTRODUCTION

Physical strain is still an occupational health problem among industrial workers in developed countries. Studies have shown that workers involvement in blue-collar task has not reduced for many decades. As a consequence, necessary measures to slow down current trends of increase in physical strain among blue-collar workers should not be taken for granted. The important point to remember is that both employers and employees should jointly adopt good occupational health and ergonomic practices. On the one hand, employers must establish certain standards to be used as a basis for evaluating optimum physical of capacity of the workers before they enter the labor market. On the other hand, workers should not neglect to diagnose their physical capacity status before joining the labor market.

When considering physical factors such as tiring for painful positions and carrying or moving heavy loads, the actual exposure to risk seemed to have remained relatively stable or even increased slightly (Eurofound 2007b). The number of employees using computer in their work increase significantly from 17% in 1984 to 75% in 2003, this has resulted into an increase in the level of physical strain of work especially, among white-collar workers and the managers (Eurofound 2005b). As far as blue-collar jobs are concern, 50% of women and 46% of men in the age group of 50-65 claimed their work as physically demanding. The corresponding figures for women and men in white-collar jobs are 24% and 13% respectively (Eurofound 2004).

Blue-collar workers aged 46-64 years experienced shoulder pain six times as much as compared to professional workers. When it comes to retirement, 47% of blue-collar workers over 60 years of age have taken early retirement, while the comparative figure for white-collar workers is 25%. Blue-collar women's health was worse compared to male workers who had the least possibility of suffering from pain (Eurofound 2006). There are substantial differences between white-collar workers and blue-collar workers as far as early retirement is concern, while 60% white-collar workers got into the retirement only 40% of blue-collar do so (Eurofound 2005a).

Evidence from previous studies suggests that physically demanding tasks such as blue-collar work increased reasonably the intensity of physical strain, particularly among low physical capacity workers. This study was part of larger studies conducted in a privately owned Finnish food factory.

2 LITERATURE REVIEW

2.1 Theoretical framework

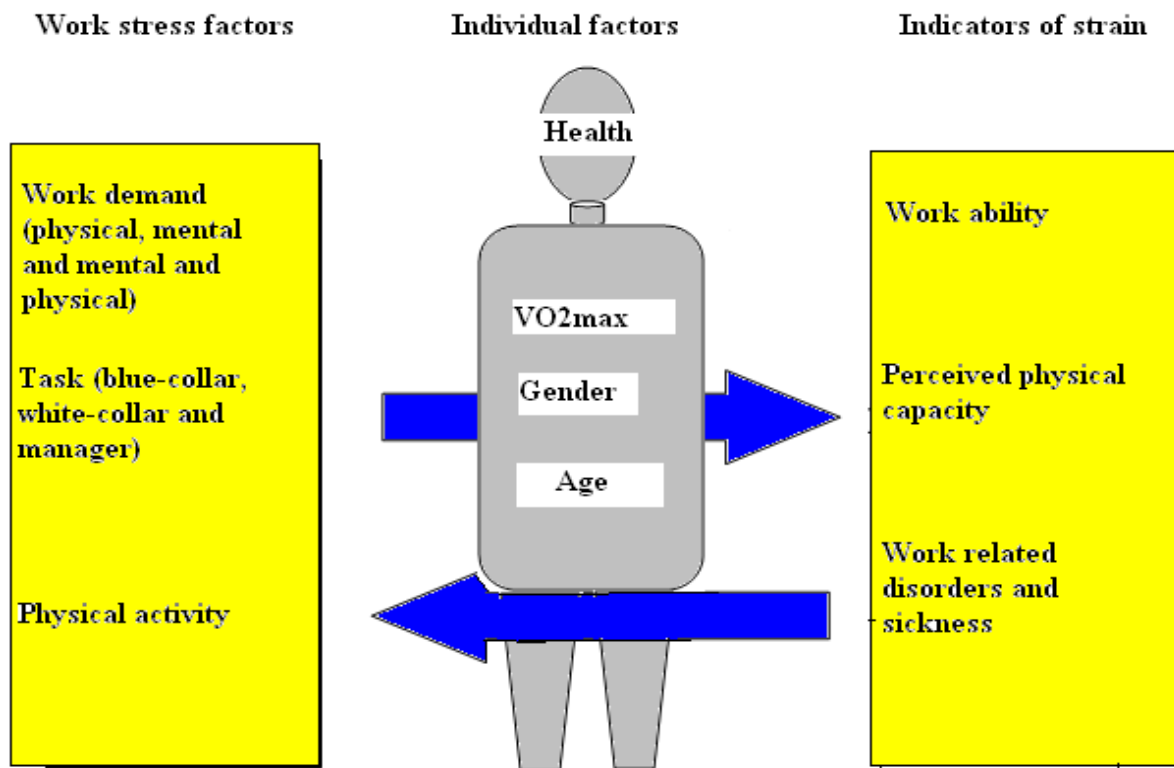


Figure1. Modified stress-strain concept (Rutenfranz 1981 and 1985).

Stress-strain concept was developed by Rutenfranz 1981 & 1985) and it is all about work stress factors, individual factors and indicators of strain. The above figure 1 provides an insight on how to balance between work stress factors and strain factors. Workers become over strained as work demands exceed their capacity (Lusa 1994). Nygård (1988) conceptualized stress (work load) factors as the causes of strain. As for the present study individual factors such as estimated physical capacity (VO2max) and health are vital in order to overcome the work stress factors e.g. work tasks and work demands. The poorer the physical capacity, work ability and health the higher the intensity of physical strain and vice versa.

The balance between stress factors and strain factors is of paramount importance in order that workers can firstly, perform work tasks to the best of their potential and capacity and secondly, attain maximum job satisfaction.

2.2 Physical capacity

2.2.1 Physical capacity and physical strain

Strain complaint rates were found to be higher firstly, in a low arm power group than a high arm power group and secondly, in a low VO₂max group than a high VO₂max group (Shimaoka et al. 1995).

2.2.2 Physical capacity by gender

Men at any given age tend to have greater physical capacity than women, simply because of higher haemoglobin concentration, larger proportion of muscle mass, greater stroke volume, higher hand grip strength, larger cross-sectional area of the muscle fibres and greater proportion of lean tissues in the upper parts of the body (Jerome et al. 2000, Libster et al. 1999, Padmavathi et al. 1999, WHO 2004, Torgen 1999, Miller et al. 1993, Crill et al. 2000, Simoneau & Bouchard 1989, Gallagher & Heymsfield 1998).

2.2.3 Physical capacity and age

Significant losses in leg muscle mass among women and men at inclined age were reported by Zamboni et al. (2003). Functional capacity declined with age, especially in women at highly advanced age (Kawamoto et al. 2004). Lower extremity functioning greatly declined with older age (Onder et al. 2002). Poorer functional ability was found among 80-84 as compared to 65-69 years old Finns (Sulander et al. 2000). There is an inverse relationship between age and maximal oxygen consumption (Weiss et al. 2006). All metabolic parameters for men and for most of women demonstrated significant losses across the age range (Wiswell et al. 2001). A progressive decline in physical capacity, characterized by diminished aerobic capacity and muscular capacity with age was reported by de Zwart et al. (1995). Greater rate of decline in strength and change in leg strength with age was directly related to the change in muscle mass in both men and women (Hughes et al. 2001).

Various components of physical work capacity such as aerobic power and capacity, muscular

strength and endurance progressively decline with advanced aging (Shephard 1999). Forrest et al. (2006) found a dramatic decline in lower extremity performance with advancing age in older women. Smaller mid thigh muscle area was found to be associated with poor lower extremity performance in well functioning older men and women (Marjolein et al. 2002). Muscle strength and functional mobility declined with age in healthy people. Besides, an accelerated decrement in muscle strength above the age of 55 was observed in women (Samson et al. 2000). Brent et al. (2004) reported significantly lower scores in the aerobic capacity test among older power line technicians. Aerobic capacity decline in each decade in women and men but a greater rate in older age groups, this decline was 3 % to 6 % per decade in the 20's and 30's but more than 20 % per decade in their 70's and beyond (Jerome et al. 2005). Onder et al. (2002) found the correlation between older age and greater decline in lower extremity function. The decline in physical capacity of work of the miners, over the age of 30 was reported by Mincheva & Nguyen (1986). Decline in muscle strength with age is associated to changes in muscle composition, decreased muscle mass due to reduced physical activity, in particular reduction of the muscle mass fraction of type two fast twitch fibres with age. Remarkably, the decline of strength with age is more pronounced in the lower extremities (Torgen 1999).

2.2.4 Association of physical capacity and work ability, work task, work demand, physical activity, health

VO₂max is positively correlated with work ability index (Bugajska et al. 2005, Goedhard 2001).

As far as retirement age is concern, the substantial differences between white-collar workers and blue-collar workers are evident, while 60% of white-collar workers move directly from employment to retirement, only 40% of blue-collar do so (Eurofound 2005a). The difference in the measured physical capacities between employees with monotonous work compared with workers with varied work tasks was reported by Faber et al. (2006). Gary et al. (2005) revealed a strong correlation of physical capacity to physical job requirements. Messing et al. (2006) claimed on the need to consider biological differences between women and men, particularly in blue-collar, manual jobs as extreme job demands may be incompatible with the

physical dimensions and capabilities of most women. Cheng et al. (2005) found the association between low job control, high job demands and work related social support.

Manual workers had significantly worse physical function than non-manual workers (Russo et al.2006). Women who had physically demanding work had greater decrease in physical capacity than women in mixed mental and physical work (Savinainen et al. 2004). Women in the group with highest job demand had significantly lower muscle endurance in the abdomen than women in the group with lowest job demands. In other words, there was a mismatch between individual physical capacity and physical work demand of work (Karlqvist et al. 2003). No any significant difference observed in maximal oxygen consumption between coal miners and industrial workers (Benavides 1992).

Physical functional capacity declines due to biological reasons and this deterioration can be significantly slowed down by regular physical activity (Ilmarinen 2005). Leino-Arjas et al. (2004) found decreased risk of poor physical functioning with vigorous leisure time physical activity while high work strenuousness increased it. An accelerated decline in VO₂max after 50 years of age in endurance-trained men due to decline in training volume was reported by (Pimentel et al. 2003). Seitsamo et al. (2007) found a strong positive effect of physical activity and functional capacity on well being of workers. Previous studies conducted among ageing home care personnel who were involved in high physical work load revealed that regular physical activity can be used to prevent deterioration of physical functional capacity (Ilmarinen 2005).

2.3 Physical strain

2.3.1 Physical strain by gender

De Zwart et al. (1999) reported substantially higher rates of musculo-skeletal complaints among women than for the men. Ahonen et al. (1990) revealed too high physical strain among female dairy farmers because of relatively low VO₂max of women. Women experienced more multiple localization of pain and had pain in neck, shoulder, arm and thigh to a greater extent than men (Andersson 1994). Women perceived greater intolerance to some work strains earlier than men, especially in a case where the work is physical one (Barbini et al. 2005).

2.3.2 Physical strain and age

According to a survey on working conditions in France conducted by Dares in 1984, 1991 and 1998, workers aged 50 or over reported less physical strain than younger age groups. For instance in 1998, employees aged 50 or over reported on average 2.1 risk factor, whereas 25-29 years old reported a level of 2.5 and for 20-25 years old the figure was 2.9. The reasons for this according to the literature are less exposure to adverse physical conditions and accidents among older people as compared to younger colleagues.

2.3.3 Association of physical strain and work ability, work task, work demand, physical activity, health

Work ability index was significantly lower among workers who used to work in painful positions (Bugajska & Lastowiecka 2005). Physical strain in good work ability category was lower than others (Yang et al.2004).

Blue-collar (manual) workers had a higher risk of being hospitalized because of low back disorders compared with white collar/non manual employees (Kaila-Kangas et al. 2006). Industrial blue collar workers had higher risk of suffering from job strain compared to white-collar workers (Eurofound 2007b). A combination of high job strain and high perceived muscular tension was associated with higher risk of developing neck pain (Wahlstrom et al.

2004). The prevalence of neck-shoulder symptoms was found to be higher among workers exposed to high job strain (Leroux et al. 2005).

Practical nurses, unskilled attendants and cleaning personnel mentioned work as more physically difficult and more monotonous both physically and mentally, compared to registered nurses, who somehow enjoyed more physical and mental well-being than the others (Gunnarsdottir et al. 2004). The increased risk of suffering from musculo-skeletal problems of neck and shoulder regions among female blue-collar workers was related to working in monotonous fixed position, working with hands and arms lifted and unsupported (Bjöksten et al. 2001). The occupation classified as manual (high physical demand) showed larger differences in injury rates between genders than did the non-manual (low physical demand) Smith & Mustard, 2004). The moderate and high perceived physical demands were significantly associated with neck, shoulder and back musculo-skeletal disorders (Alison et al. 2003).

The number of employees using computer in their work increase significantly from 17% in 1984 to 75% in 2003, this has resulted to an increase in the level of physical strain of work especially, among white-collar workers and the managers. Moreover, women use computer more intensively than men. The computer use was highest for the middle-aged and lower among older workers (Eurofound, 2006b). The use of computer has resulted in more qualified work and less physical strain. However, those who worked with computer permanently clearly showed more signs of physical and mental strain than those who used the computers only on part time basis (Andries et al., 2002). Poor physical work environment and placement of the key board increased the risk of neck pain. Moreover, among individual factors, female sex was a strong predictor for neck pain (Korhonen et al. 2003).

Ariens et al. (2001) found firstly, a positive relation between the percentages of the working time in a sitting position and neck pain and secondly, a positive correlation between neck flexion and neck pain. The dissatisfaction with the physical work environment was associated with strain (Bridger et al. 2007). Heavy work was found to be one of the most significant risk factor for back, neck, shoulder and arm pains or complaints (Eurofound 2006a). Occupational role was found to correlate positively with personal strain (Yang et al. 2004).

Lifting, bending, stooping, sitting or standing work postures and heavy work was found to be associated with the risk of low back pain. However, self rated and leisure-time physical

activity was found not to associate with the risk of low back pain. But, sedentary levels of physical activity were inversely related with risk of low back pain (Yip et al. 2002). Workers with high strain had 2.6-5.2 metabolic equivalents hours/week less than their counterparts with low strain. In addition, active jobs were associated with lower mean of metabolic equivalent hours in men and older workers (Kouvonen et al. 2005).

High job strain significantly associated with components of health related quality of life (Lerner et al.1994). High job strain in female and male general practitioners i.e. low control and high work demand exhibited more than threefold increased risk of impaired general health compared with those with medium job strain (Sundquist & Johansson 2000). High job strain was associated with lower self-rated health (Staland-Nyman et al. 2008).

2.4 Work ability

Work ability is defined as a balance between works demands and personal resources. Personal resources embed health and ability, education and competence, and values and attitudes (Ilmarinen 2005).

2.4.1 Work ability by gender

No any gender difference was reported as far as work ability is concern (Tuomi et al. 2001 & 2004). On the contrary, (Costa et al. 2005, Yang et al.2003) found higher work ability index scores among female workers as opposed to males.

2.4.2 Work ability and age

Work ability decreased with increase in age (Pohjonen 2001, Ilmarinen et al.1997, Liira et al.2000).

2.4.3 Association of work ability and work task, work demand, physical activity, health

(Tuomi et al. 2004) found higher work ability scores of managers and white-collar employers than those of blue-collar. The work ability index scores of manual workers declined rapidly beyond the age of 35 years and beyond age of 45 for professional and clerical workers (Lin et al. 2005). Work ability rate was found to be lower among unskilled blue-collar workers, compared to professions and managerial staff (Eurofound 2007a).

Professional competences and good work ability associates with a high quality of work and the enjoyment of staying in one's job (Tuomi et al. 2001). The observed differences in work ability and job demands were more positive among blue-collar workers than among white-collar workers (Lohevaara et al. 1999). Significantly poorer work ability of physical workers than mental workers among Finnish aging men and women was reported by (Tuomi et al. 2001). Preventing poor work ability and promoting excellent work ability depends on physical factors and work tasks (Lindberg et al.2006).

Martinez & Latorre (2006) conducted a cross-sectional study in order to identify the dimensions of health associated with work ability. The results revealed the association between better physical and mental health with greater work ability.

2.5 Summary of the literature

Low physical capacity associated with higher intensity of physical strain. Female workers had lower physical capacity compared to males. Physical capacity declined with increase in age. Blue-collar (manual) workers had worse physical capacity than white-collar (non-manual) workers. The decline in physical capacity can be slowed down by regular physical activity.

Female workers had higher intensity of physical strain than males. Older workers had higher intensity of physical strain than younger ones. Blue-collar (manual) workers are at higher risk of suffering from physical strain than white-collar (non-manual) workers. Furthermore, white-collar workers and managers had greater intensity of physical strain due to regular use of computers. High job strain was found to be a source of impaired general health than medium strain job.

Whereas some studies reported pronounced decline in work ability among women than in men, other studies did not find any gender difference in work ability. Work ability decreased with increase in age. Higher work ability scores were revealed among managers and white-collar employees. Better physical and mental health was found to be associated with greater work ability.

3. AIMS OF THE STUDY

The major goal of this study was to investigate the relationship between physical capacity and physical strain among workers in a food factory. In addition, this study also examined the association between physical capacity, physical strain and work ability.

Specifically the study aimed to:

- Investigate the variation of physical capacity with gender, age, work ability, work task (blue-collar, white-collar, manager), work demand (mental, physical, mental & physical, physical activity and health.
- Investigate how the intensity of physical strain varies with gender, age, work ability, work tasks (blue-collar, white-collar, manager), work demand (mental, physical, mental & physical), physical activity and health.

4. SUBJECTS AND METHODS

4.1 Subjects

This study involved 873 food factory workers (women, n = 604 and men, n = 269) aged 19-65 years. The sample mean age was 40.5 and it composed of 603(69.1%) blue-collar workers, 85(9.7%) managers and 182(20.8%) white-collar workers.

The number/proportion (%) of women and men in blue-collar, managers and white-collar task was 428(71.0%), 34(40.0%) & 139(76.4%) and 175(29.0%), 51(60.0%) & 43(23.6%) respectively. The number/proportion (%) of women and men in mental, physical, mixed mental/physical work was 139(63.8%), 278(72.0%) & 177(69.1%) and 79(36.2%), 108(28.0%), 79(30.9%) respectively.

Total number of questionnaires administered during data collection was 1995, of this only 1120 subjects responded. Among those who responded only 873 completed consent forms. Therefore, the response rate was 56% when referring to only those workers who answered the questionnaires. Considering only those who completed the consent forms, the response rate was 77.9%.

4.2 Methods and study designs

This research involved a cross-sectional survey study, conducted in order to investigate the association between the variables i.e. independent variables (presumed cause,) and the dependent (outcome) variables. During data analysis physical capacity was treated as an independent variable i.e. presumed cause while, physical strain as a dependent variable or outcome variable.

Data was collected using a cross-sectional survey-questionnaire. The subjects were asked to rate their perceived physical capacity, health condition, work ability, physical activity and physical strains based on 10-point rating scale, ranging from 1(very low) to 10 (very high). Except for the physical strain of work which was rated based on 15 points rating scale, which usually ranges from 6 (weak) to 20 (excellent) .

Number of variables was used in this study, but regarding study objectives the following were the main variables selected for data analysis. Perceived capacity, gender, task (blue collar, white collar, manager), work demands mainly (physical, mental, physical/mental), work ability now days (0-10), physical strain of work (6-20), strain of hands/upper extremities (0-10), strain of feet/lower extremities (0-10), strain of low back (0-10), strain of neck/shoulder (0-10), physical capacity compared with peers (0-10) and physical activity group (0-7).

The following variables were in categorical form: Gender (Female or Male), work task (blue-collar, manager, white-collar), work demand (physical, mental, mental and physical) and age. Two new variables were formed and they include, body mass index (BMI) and VO₂max. The BMI was calculated in accordance with the following equation: $BMI (kg/m^{2}) = \text{Weight} / (\text{height} / 100)^{2}$. Weight was measured in kilograms and height in centimetres. Height was divided by 100 in order to convert it into metre (Jackson et al.1990). Moreover, BMI was classified as Underweight (BMI<18.50), normal (BMI=18.50-24.99), overweight (BMI≥25.00), obese (BMI≥30.00. (WHO 2006).

$VO_{2}max (ml/kg/min) = 56.363 + 1.921 * \text{physical activity group} - 0.381 * \text{age} - 0.754 * \text{BMI} + 10.987 * \text{gender}$; women=0, men=1(Jackson et al. 1990).

Age was categorized as age group 1 (age ≤19), age group 2 (age 20-29), age group 3 (age 30-39), age group 4 (age 40-49), age group 5 (age 50-59) and age group 6 (age ≥60) years.

Sources of literature

Literature was searched from the University of Tampere on-line library, using Pub- med, Elsevier and Medline as free archive of biomedical and life science journals/articles. The following key words were used during the literature search. Physical capacity, physical strain, work ability, maximal oxygen consumption, work load, work task, work demands, blue-collar task, white-collar task, manual work.

4.3 Statistical data analysis

Data analysis was performed using Statistical Package for Social Sciences (SPSS) version 13.0. The association between the variables was analysed using one-way analysis of variance (ANOVA), especially in the case where independent variables had more than two categories e.g. work task (blue-collar, white-collar and manager), work demand (physical, mental and mental & physical). Pearson correlation was used to analyse the association between independent and dependent variables both in continuous form and the correlations were significant both at 0.01 and 0.05 levels (2-tailed).

5. RESULTS

5.1 Physical strain, physical capacity and work ability by gender

As can be seen from table 1 below, no gender difference was found as far as perceived capacity and work ability are concerned. However, estimated capacity was significantly higher in men than in women. Remarkable gender difference in the intensity of strain was observed. Female workers had higher intensity of physical strain than their male counterparts (Table 1).

Table 1. Physical strain, physical capacity and work ability by gender, p-values for differences between genders.

Variables	Gender	Mean	SD	p-value
Physical strain of work(6-20)	Women	12.9	3.8	0.0016
	Men	12.2	3.7	
Strain of hands/upper extremity(0-10)	Women	6.5	2.7	0.001
	Men	5.3	2.9	
Strain of neck / shoulder (0-10)	Women	7.4	2.3	0.001
	Men	6.2	2.6	
Strain of low back (0-10)	Women	6.0	2.7	0.020
	Men	5.6	2.7	

Strain of feet /lower extremity (0- 10)	Women	5.3	3.0	0.025
	Men (264)	4.9	2.9	
Perceived capacity(0-10)	Women	7.4	1.4	0.513
	Men	7.4	1.7	
VO2max (mL/kg/min)	Women	40.4	7.3	0.001
	Men	51.5	7.4	
Work ability now days(0- 10)	Women	8.4	1.2	0.950
	Men	8.3	1.4	

5.2 The relationship between physical strain, physical capacity, work ability and age group.

Physical strain of work, estimated capacity and work ability declined substantially with increase in age. Strain of neck/shoulders, hands/upper extremities and low back also decreased with increase in age, but this decrease was not statistically significant. On the contrary, strain of feet/lower extremity increased with increase in age, although this increase was not statistically significant (Table 2)

Table 2. The relationship between physical strain, physical capacity and work ability by age group, p-values for differences between age groups.

Variables		Age group(1-6)						p-value
Physical strain work(6-20)	Mean	13.0	13.4	12.7	12.1	12.6	12.1	0.035
	±SD	2.8	3.5	3.8	3.9	3.7	4.7	
Strain of neck/shoulder(0-10)	Mean	7.0	7.1	7.2	7.1	6.7	6.5	0.417
	±SD	1.4	2.3	2.4	2.5	2.6	2.8	
Strain of hands/upper extremity(0-10)	Mean	6.5	6.2	6.2	6.2	6.1	5.2	0.575
	±SD	0.7	2.7	2.9	2.9	2.9	3.0	
Strain of low back(0-10)	Mean	6.0	6.3	5.8	5.7	5.7	5.7	0.237
	±SD	0.0	2.6	2.8	2.7	2.7	3.0	
Strain of feet/lower extremity(0-10)	Mean	5.5	4.9	5.1	5.2	5.7	4.9	0.207
	±SD	3.5	2.8	3.0	3.0	2.8	3.4	
Perceived capacity(0-10)	Mean	6.5	7.5	7.5	7.2	7.4	7.8	0.293
	±SD	2.1	1.6	1.6	1.6	1.4	1.1	
Estimated capacity	Mean	51.8	50.5	46.8	42.2	37.1	36.2	0.001
	±SD	6.7	7.1	8.0	7.6	7.4	6.3	
Work ability(0-10)	Mean	9.0	8.7	8.4	8.4	8.0	7.9	0.001
	±SD	1.4	1.2	1.3	1.2	1.2	1.0	

N.B: Age group1 (age ≤19), age group 2 (age 20–29), age group 3 (age 30–39), age group 4 (age 40–49), age group 5 (age 50–59) and age group 6 (age ≥60) years.

5.3 The association between physical strain, work ability and physical capacity

Physical strain of work and strain of different parts of the body declined with increase in perceived and estimated capacity. Strain of hands/upper extremities, strain of neck/shoulders, and strain of feet/lower extremity declined significantly with increase in estimated capacity. The same decline in the intensity of strain was not statistically significant in the case of physical strain of work and the strain of lower back. Work ability increased sufficiently with increase in perceived and estimated (Table 3).

Table 3. Association of physical strain, work ability and physical capacity, Pearson correlation coefficients and p-values.

Variables	Perceived capacity		Estimated capacity	
	Pearson correlation	Sig.(2-tailed)	Pearson correlation	Sig.(2-tailed)
Physical strain of work(6-20)	- 0.034	0.321	- 0.017	0.630
Strain of hands/upper extremity(0-10)	- 0.036	0.295	- 0.121**	0.001
Strain of neck / shoulder (0-10)	- 0.045	0.188	- 0.147**	0.001
Strain of low back (0-10)	- 0.028	0.419	- 0.021	0.553
Strain of feet /lower extremity (0-10)	- 0.015	0.651	- 0.107**	0.002
Work ability(0-10)	0.538**	0.001	0.215**	0.001

5.4 Physical strain in relation to work ability and age

Physical strain of work and strain of different parts of the body declined with increase in age and work ability, except for the strain of feet/lower extremity which on the contrary, increased significantly with age. Strain of low back declined reasonably with increase in age. Strain of hands/upper extremity, neck/shoulder declined with increase in age but this decline was not statistically significant. Physical strain of work and strain of different parts of the body declined sufficiently with increase in work ability (Table 4).

Table 4. Physical strain in relation to work ability and age, Pearson correlation coefficients and p-values.

Variables	Work ability(0-10)		Age	
	Pearson correlation	Sig.(2-tailed)	Pearson correlation	Sig.(2-tailed)
Physical strain of work(6-20)	- 0.209**	0.001	-0.093**	0.006
Strain of hands/upper extremity(0-10)	- 0.145**	0.001	-0.032	0.345
Strain of neck / shoulder (0-10)	- 0.090**	0.008	-0.058	0.087
Strain of low back (0-10)	- 0.191**	0.001	-0.071*	0.036
Strain of feet /lower extremity (0-10)	-0.180**	0.001	0.063	0.064

5.5 The association between physical strain, physical capacity, work ability and health

While physical strain of work and strain of different parts of the body declined significantly with improved health. By contrast, perceived capacity, estimated capacity and work ability increased substantially with improved health (Table 5)

Table 5. Association of physical strain, physical capacity, work ability and health, Pearson correlation coefficients and p-values.

Variables	Health(0-10)	
	Pearson Correlation	Sig.(2.tailed)
Physical strain of work(6-20)	- 0.119**	0.001
Strain of hands/upper extremity(0-10)	- 0.082*	0.016
Strain of neck / shoulder (0-10)	- 0.077*	0.023
Strain of low back (0-10)	- 0.106**	0.002
Strain of feet /lower extremity (0-10)	- 0.076*	0.026
Perceived capacity(0-10)	0.803**	0.001
VO2max(estimated capacity)	0.209**	0.001
Work ability now days(0-10)	0.662**	0.001

5.6 The association between physical strain, physical capacity, work ability and physical activity

Perceived capacity, estimated capacity and work ability increased substantially with increase in physical activity intensity. Physical strain of work and strain of different parts of the body declined with increase in physical activity intensity, however this decline was statistically significant only in the case of strain of neck/shoulders (Table 6).

Table 6. Association of physical strain, physical capacity, work ability and physical activity, Pearson correlation coefficients and p-values.

Variables	Physical activity group(0-7)	
	Pearson Correlation	Sig.(2.tailed)
Physical strain of work(6-20)	- 0.059	0.083
Strain of hands/upper extremity(0-10)	- 0.043	0.204
Strain of neck / shoulder (0-10)	- 0.085*	0.012
Strain of low back (0-10)	- 0.005	0.884
Strain of feet /lower extremity (0-10)	- 0.049	0.153
Perceived capacity(0-10)	0.366**	0.001
VO2max	0.553**	0.001
Work ability now days(0-10)	0.167**	0.001

5.7 Physical strain, physical capacity and work ability in relation to work tasks and work demand.

The intensity of physical strain was highest among blue-collar workers in comparison with white-collar workers and managers. In addition, the association between the physical strain of work and the strain of different parts of the body with work task was statistically significant. Both perceived and estimated capacities were lowest among blue collar workers in comparison with white-collar workers and managers. While the relationship between estimated capacity and work task was statistically significant. By contrast, the relationship between perceived capacity and work task was not statistically significant. Blue-collar workers had the lowest work ability in comparison with managers and white-collar workers (Table 7).

The intensity of physical strain was highest among physical workers in comparison with mixed mental/physical and mental workers. Whereas the association of physical strain of work and strain of different parts of the body with work demand was statistically significant, by contrast, the association of physical capacity and work demand was not statistically significant. Perceived physical capacity was lower among mixed physical/mental and physical workers in comparison with mental workers. Unexpectedly, estimated capacity was highest among physical workers than in mixed physical/mental and mental workers. Work ability was sufficiently low among physical, mixed mental/ physical workers compared with mental workers (Table 8).

Table 7. Physical strain, physical capacity and work ability in relation to work task, p-values for differences between work task.

Variables	Work task			p-value	
	Blue-collar	manager	White-collar		
Physical strain of work(6-20)	Mean ±SD	14.2 3.0	9.2 3.1	9.1 2.9	0.001
Strain of hands/upper extremity(0-10)	Mean ±SD	7.0 2.4	3.0 2.5	4.8 2.8	0.001
Strain of neck / shoulder (0-10)	Mean ±SD	7.3 2.3	5.4 2.6	6.7 2.5	0.001
Strain of low back (0-10)	Mean ±SD	6.7 2.4	3.3 2.4	4.3 2.5	0.001
Strain of feet /lower extremity (0-10)	Mean ±SD	6.1 2.6	2.8 2.7	3.1 2.5	0.001
Perceived physical capacity(0-10)	Mean ±SD	7.4 1.6	7.6 1.4	7.4 1.5	0.481
VO2max(mL/Kg/min)	Mean ±SD	44.3 8.9	45.8 7.7	41.6 9.1	0.001
Work ability now days(0-10)	Mean ±SD	8.2 1.3	8.6 1.0	8.7 0.9	0.001

Table 8. Physical capacity and work ability in relation to work demand, p-values for differences between work demand.

Variables	Work demand				
	Mental	Physical	Mental /physical	p-value	
Physical strain of work(6-20)	Mean ±SD	8.5 2.6	14.4 2.8	13.5 3.2	0.001
Strain of hands/upper extremity(0-10)	Mean ±SD	3.9 2.9	7.0 2.5	6.7 2.4	0.001
Strain of neck / shoulder (0-10)	Mean ±SD	6.2 2.6	7.4 2.4	7.2 2.3	0.001
Strain of low back (0-10)	Mean ±SD	3.7 2.5	6.7 2.3	6.4 2.6	0.001
Strain of feet /lower extremity (0-10)	Mean ±SD	2.6 2.3	6.0 2.6	6.2 2.7	0.001
Perceived capacity	Mean ±SD	7.5 1.5	7.4 1.5	7.2 1.6	0.294
VO2max(estimated capacity)	Mean ±SD	43.4 8.7	44.3 9.4	43.6 8.4	0.479
Work ability now days(0-10)	Mean ±SD	8.7 1.0	8.2 1.3	8.2 1.3	0.001

6. DISCUSSION

6.1 Methods

In this study VO₂max was predicted from body composition, gender (dummy i.e.0,1 for female and male respectively), age and self reported activity based on non exercise(N-Ex) regression equation: $VO_{2peak} = 56.363 + 1.921(PA-R) - 0.381(Age) - 0.754(BMI) + 10.987(F=0, M=1)$. Previous studies found that non- exercise functional capacity prediction model to be more accurate than Astrand sub-maximal prediction method (Jackson et al.1990). Bradshaw (2003) described Non-Exercise regression equation as less expensive, time efficient and realistic for large groups as it does not need one to perform a maximal or sub maximal exercise tests as compared to maximal graded exercise which requires costly equipments, trained personnel and time management .

According to (Sherman 2003, Kilbom 1990) rating scale 0-10 or 10-point scale can be used to quantify subjective perceptions of discomfort ranging from 0 (nothing at all) to 10 (Extremely strong). This study identified advantages of rating scale as being easy to use, effective in evaluating intermittent task and repeated reliability. On the other hand, the study cited the disadvantages as inability of subjects' to differentiate quite often between variables and the entire work task, ratings being influenced by previous experience and motivation and the fact that individuals interpret the scale differently.

6.2. Limitation of the study

The current study was not specifically designed to account for other possible risk factors of physical strain such as the effect of smoking, obesity, physical exercise intensity and dual role among women e.g. working and taking care of family. However, it should not be forgotten that this was a simply a cross- sectional survey study. Previous study by Ratzlaff et al. (2007) found association between active lifestyle during leisure time with lower prevalence of work related repetitive strain injury. Moreover, female sex, obesity, smoking, age, work related stress and work physical demands were associated with repetitive strain injury. It is suggested

that the association of these factors will be investigated in the future studies.

6.3 Physical capacity

6.3.1 Physical capacity in relation to physical strain

The present study found decline in the intensity of physical strain with increase in perceived and estimated capacity. This signifies that good physical capacity is essential in order to reduce the problem of work related physical strain. This finding is in agreement with (Shimaoka et al. 1995) findings which showed significantly higher strain complaint rates among low VO₂max group than high VO₂max group. (Gray et al. 2005) found lower incidence of low back among workers who demonstrated their physical capabilities compared to those who expressed their physical abilities and strength as poor.

6.3.2 Physical capacity in relation to gender

The present study did not find statistically significant gender difference in perceived capacity. However, remarkable gender difference was observed in estimated capacity. The mean VO₂max value was 40.40 ml/kg/min and 51 ml/kg/min for women and men respectively. These findings of the current study are consistent with (Libster et al. 1999, Jerome et al. 2000) findings which showed that men tend to have higher maximal oxygen consumption than women because of higher haemoglobin concentration, a larger proportion of muscle mass, and a greater stroke volume. The greater gender difference in upper body strength was subject to lower proportion of their lean tissue located in the upper body among women (Gallagher & Heymfield 1999). The cross-sectional area of three major fibre types was found to be larger for the men compared to the women (Crill et al. 2000, Miller et al. 1993)

6.3.3 Physical capacity in relation to age

The current study found decline in physical capacity with increase in age. These findings of the current study are consistent with (Shephard, 1999; de- Zwart et al.1995) findings which showed a progressive decline in physical capacity with age because of a reduction in various components of physical capacity such as aerobic capacity, muscular strength/capacity and endurance with ageing. Muscle strength deteriorates with age as a result of changes in muscle composition, decreased muscle mass due to reduced physical activity, and loss of muscle

fibres (Torgen 1999). Cardiovascular capacity and muscular strength decline with increasing age (Andersson 2004). Zamboni et al. (2003) found significant losses in leg muscle mass among women and men aged 68-78 years. Decline in functional capacity with advanced age especially among women age 65 and older was reported by Kawamoto et al. (2004).

6.3.4 Physical capacity in relation to work ability, work task, work demand, physical activity and health

The results of present study showed that both perceived and estimated physical capacity increased substantially with increase in work ability. Work ability index and VO₂max correlated positively (Bugjska et al. 2005, Goedhard 2001).

Both perceived and estimated capacities were greatest among managers in comparison with blue-collar and white-collar workers. There was a little difference in estimated capacity between blue-collar and managers, this slight difference may be attributable to the low mean age of blue collar workers. Age wise managers are older than blue-collar workers. Estimated capacity was expected to be lower among managers, due to the fact that maximal aerobic capacity usually declines with age, yet blue-collar workers had lower estimated capacity than managers, this means that the influence of work task is greater on the capacity of an individual blue-collar worker than the effect age has on the estimated capacity. This study is in conformity with previous study by Yoopat et al. (2002) among Thai blue collar workers, which showed poor mean age related VO₂max of male and female workers. Messin et al. (2006) found incompatibility mostly in women as far as blue-collar, manual works and physical dimensions and capacities are concern. Functional capacity declined greatly due to low job control and high job demand (Cheng et al. (2005). Manual workers aged 80 and older were found to have significantly worse physical functioning (Russo et al. 2006). Physical work load did not seem to have training effect the view which is contrary to previous thoughts that physical work load maintains and increases physical capacity (Nygård 1988).

Present study found that both perceived and estimated capacity mean values were lower among physical workers in comparison with mixed mental/physical and mental workers. Estimated capacity was slightly higher among physical workers as compared to mental and mental/physical. The reasons for this might be due to low mean age of physical workers. There was greater decline in physical capacity among women involved in physically

demanding works than women in mixed mental and physical work (Savinainen et al. 2004). Lower abdomen muscle endurance was found among women with high job demands as opposed to those with low job demands (Karlqvist et al. 2003)

According to the results of this study both perceived and estimated capacity improved with increase in physical activity intensity. Decline in muscle strength with age was associated with decrease in muscle mass due to reduced physical activity (Torgen 1999). Decline in functional capacity can be slowed down by regular physical activity (Ilmarinen 2005). Leino-Arja et al. (2004) found decreased risk of poor physical functioning with vigorous leisure-time physical activity.

The current study found that perceived health significantly deteriorated among blue-collar workers compared with white-collar workers and managers. Perceived health complaint was lower among white-collar employees compared to blue-collar workers (Broersen et al. 1996, Martikainen et al. 2004). Skilled workers had better health than blue-collar workers (Korda et al. 2002). Lower well-being scores among blue-collar workers was reported by Yu & Wang (1993)

6.4 Physical Strain

6.4.1 Physical strain in relation to gender

Present study found gender difference in the intensity of physical strain. A possible explanation for this might be that women have lower physical capacity compared to men. There was a slight gender difference in perceived capacity but in the case of estimated capacity the difference was sufficiently high. Biological differences in physique, muscle strength, capacity to perform particular tasks, weight, fat distribution, metabolism or hormonal systems may result into varying intensity of strain (WHO 2004). Physical load may exert greater strain on women than in men because on average men are taller, larger and heavier than women, and the fact that women menstruate and give birth (WHO 2004). A substantially high rate of musculoskeletal complaints were found among women than in men (de Zwart et al. 2006). Ahonen et al. (1990) reported higher physical strain among female farmers due to low maximal oxygen consumption. Women experience neck, shoulder, arm, and thigh pain to a greater extent than men (Andersson 1994). Women were reported to have higher rates of strain than men (Bridger et al. 2007).

6.4.2 Physical strain in relation to age

Present study found a decline in the intensity of physical strain of work, hands/upper extremities, neck/shoulders, lower back with increase in age. Contrary to expectations, the intensity of physical strain declined with age. This unexpected decline might be due to the possibility for the older workers to have developed coping skills with their work. This study is in conformity with the previous survey on working conditions in France conducted by Dares (1984, 1991 and 1998) which reported less physical strain among older workers than younger age groups. The findings from the previous study explained the reasons behind this decline as the lesser possibility of older workers to be exposed than their younger counterparts to such adverse conditions as physical strain, vibration and extreme temperature.

Conversely, the strain of feet/lower extremities increased with age, a possible explanation for this might be due to the deterioration in physical capacity with advancing age. Torgren (1999) found the decline of strength with age, which is more pronounced in the lower extremities.

Greatest decline especially for lower extremity function is associated with old age (Onder et al. 2002). Forrest et al. (2006) revealed dramatic decline in lower extremity performance with advancing age in older women.

6.4.3 Physical strain in relation to work ability, work task, work demand, physical activity and health

The current study found inverse relationship between work ability and physical strain. The present findings seem to be consistent with previous research findings which showed firstly, lower work ability index among workers who work in painful positions and secondly, lower intensity of physical strain in good work ability category (Bugjska et al.2005, Goedhard 2001)

Blue-collar workers had higher intensity of physical strain than white-collar workers and managers. Kaila-Kangas et al. (2006) revealed higher risk of being hospitalized because of low back disorders among blue-collar (manual) workers compared with white-collar employees (non-manual). High prevalence of neck-shoulder symptoms were found among workers exposed to high job strain (Leroux et al. 2005). Bjöksten et al. (2001) reported high risk of suffering from musculo-skeletal problems of neck, shoulder and thoracic spine among female blue-collar workers.

Based on the results of this study it can clearly be understood that physical strain of work and strain of different parts of the body was sufficiently high in physically demanding work. Ariens et al. (2001) found a positively significant relationship between the percentage of the working time in a sitting position and the neck pain. Higher work strain was associated with a stronger relation between work demand and work control (John et al. 2006). Sundquist & Johansson (2000) found high job strain among general practitioners as a result of low control and high work demand.

The current study found decline in the intensity of physical strain with increase in physical activity intensity. Previous study by Yip (2002) found the risk of low back pain to be associated with lifting, bending, stooping, sitting and standing work postures. However, self-rated physical activity and leisure-time physical activity were not found to be associated with incidence of low back pain but, sedentary levels of physical activity were inversely related to the risk of low back pain.

The current study found the decline in the intensity of physical strain with improved health. This study finding is consistent with (Staland-Nyman et al.2008) findings which showed the association between high job strain and lower self-rated health

6.5 Work ability

6.5.1 Work ability by gender

The current study did not find gender difference in work ability. This finding is in agreement with (Tuomi et al, 2001 & 2004) findings which showed no gender difference in work ability. On the contrary, Costa et al. (2005) revealed pronounced decline in work ability index among women compared to men.

6.5.2 Work ability in relation to age

The present study found a decline in work ability with increasing age. This may to some extent be the consequence of the deterioration in physical capacity with advancing age. Work ability declined between the ages of 40 and 44 years and sharper decrease occurred after 55 years among old female home care workers. (Liira et al.2000, Pohjonen, 2001, Ilmarinen, 1997). The work ability of Finnish municipal aging workers was found to deteriorate prematurely (Nurminen et al. 2005).

6.5.3 Work ability in relation to work task and work demand

The current study found poor work ability among blue-collar workers compared with white-collar workers and managers. This finding of the current study is consistent with (Tuomi et al. 2004, Ilmarinen 1997) findings which showed higher work ability scores of managers and white-collar workers in comparison with blue-collar workers.

The present study results found lower work ability scores among physical, mixed mental/physical workers compared with mental workers. This finding is in agreement with Tuomi et al. (2001) findings which showed poorer work ability of physical workers than mental workers. The work ability index scores for office workers, laboratory workers and field workers were found to be 44.9, 43.2 and 39.7 respectively (Bresic et al. 2007)

7 CONCLUSION

One of the more significant findings to emerge from this study is that physical capacity was a prerequisite for the purpose of achieving better work ability and health among food factory workers as poor physical capacity was directly associated with greater intensity of physical strain. Physically demanding tasks especially among blue-collar workers increased the likelihood of workers to suffer greater intensity of physical strain. Gender differences in the intensity of strain was revealed, this gender difference was greatly attributable to low physical capacity among female employees. Perceived health and work ability was poor among blue-collar, high strain and low physical capacity workers. Lastly, physical capacity declined with advancing age.

Recommendations

The current findings add substantially to our understanding of the phenomenon of physical strain and how it is associated to physical capacity. In addition, findings from this study may be useful to workers, employers and managers in their endeavour to prevent and manage the work related physical strain. Physical strain adversely affects job performance in industrial sector due to lost work time and productivity because of absenteeism, long term sickness and early retirement. It is therefore the duty of enterprises, employers and managers to consider beforehand physical capacity requirements for their employees. Moreover, they should organize on job training programs which will enhance workers awareness of their health and well-being through utilization of modern ergonomic practices.

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