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AGE, GENDER, AND MUSCLE STRENGTH: A STUDY BASED ON INDONESIAN SAMPLES

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Abstract

Age and gender have been commonly used as a main criterion in accepting a job aplicant, but it is usually not clear how these affect job performance. While a number of recent studies have been done that describe the relationships between age, gender, and participants capacity (e.g., muscle strength), the results have been inconclusive. In Indonesia, in particular, such issues have been rarely investigated, and it is still important to study the issue since the relationships between these factors are population-specific. This study aimed at describing the relationships between age and muscle strength among workers for both genders. Ninety-six male and female workers (aged 18–65) were recruited in this study, and data on handgrip and lower back strength were collected. Findings of this study show that peak hand-grip strength occured at the age of around 35-40 years of age, regardless of gender. Maximum lower back strengh was identified at the age of 31-35 years old (for males) and 26-30 years old (for females). Comparisons between two extreme age groups (18-20 vs. 61-65 years of age) showed a mean strength decline of 50% for hand-grip and 30% for the lower back. For both protocols, female participants tended to have lower muscle strength (70-80% of their male counterparts). Findings of this study can be used as a basis in evaluating physical requirements of a job, and the corresponding factors (age and gender) relevant for the job.

Abstrak

Usia, Gender, dan Kekuatan Otot: Suatu Kajian berdasarkan Responden Orang Indonesia. Umur dan jenis kelamin telah umum digunakan sebagai kriteria utama dalam penerimaan pekerja, tetapi biasanya tidak jelas apakah usia dan jenis kelamin ini dapat mempengaruhi kinerja kerja. Sementara sejumlah penelitian terbaru yang telah dilakukan menggambarkan hubungan antara umur, jenis kelamin, dan kemampuan manusia (misalnya: kekuatan otot), hasilnya tidak meyakinkan. Di Indonesia, khususnya, isu-isu seperti itu telah jarang dilakukan penelitian, dan hal ini masih penting untuk dipelajari karena hubungan antara faktor-faktor ini mempunyai hasil yang berbeda pada populasi yang berbeda. Penelitian ini bertujuan untuk mendeskripsikan hubungan antara usia dan kekuatan otot antara para pekerja untuk kedua jenis kelamin. Sembilan puluh enam pekerja laki-laki dan perempuan berusia (18-65) tahun direkrut dalam penelitian ini, dan data pada kekuatan genggaman dan kekuatan punggung bawah dikumpulkan. Hasil penelitian ini menunjukkan bahwa puncak kekuatan genggaman terjadi pada usia sekitar 35-40 tahun. Kekuatan maksimum punggung bawah diidentifikasi pada usia 31-35 tahun (untuk pria) dan 26-30 tahun (untuk wanita). Perbandingan antara dua kelompok usia ekstrim (18-20 vs 61-65) tahun menunjukkan penurunan kekuatan rata-rata 50% untuk tangan dan 30% untuk punggung bawah. Untuk kedua protokol, peserta perempuan cenderung memiliki kekuatan otot yang lebih rendah 70-80% dari pria. Hasil penelitian ini dapat digunakan sebagai dasar dalam mengevaluasi persyaratan fisik pekerjaan, dan faktor-faktor yang sesuai (usia dan jenis kelamin) yang relevan untuk suatu jenis pekerjaan tertentu.

Keywords: age, capability, gender, handgrip strength, lower back strength

1. Introduction

Companies usually set an age (and gender) criterion for the various types of work when hiring its employees. Age restriction was also indicated by the Department of Labor, where the minimum age of the employees is slightly different for different types of jobs. The International Labor Organization/ILO (Law No. 20, 1999) states that the minimum age limit for industrial workers are 18 years old, and 15 years of age for non-

industrial worker. Regulations set forth by the Ministry of Manpower of the Republic of Indonesia (in 1995) indicate that retirements can be applied to those between the ages of 55 to 60 years old.

Age restrictions have been discussed (and debated), mainly because at the retirement age, some claim that they can still perform the work. The policy on age limitations are also different across ministries in Indonesia. Nevertheless, understanding the relationships between age, gender, and work capability is still of interest, both abroad [1] and in Indonesia [2].

Requirements on the job may be physical, mental, and/or psycho-social [3]. The nature of physical needs is energetic, biomechanic, or environmental. Mental needs are in the cognitive domain, which includes those such as concentration, memory, decision making, or attention. Psycho-social requirements are related to things such as emotions, participants relations, autonomy, time pressure, as well as unusual working hours.

Specific to the area of biomechanics, the main objective is to enhance the performance between workers and the machines, tools, and materials that they are using, while at the same time minimizing the risk of musculoskeletal injuries [4]. Some inherent individual factors, such as gender, age, and their correlations with biomechanical capabilities, including strength, fatigue, and endurance have always been of interest. The work by Lindel [5], for instance, exemplifies this issue. This investigator studied isometric, concentric, and eccentric muscle strength of 654 male and female participants (20-93 years of age). This study demonstrated a close relationship between age and muscle strength, with 8-10% decline for every 10 year increase in age across gender. Similar finding was also reported by Frontera when measuring the triceps and knee muscle strength for the purpose of job design [6]. In general, these and other studies (e.g., Garg [7]) demontrated a decline in muscle strength as one gets older. The decline may increase the likelihood of accidents and, to some extent, can create hesitance for work for the older worker.

While a number of studies have been conducted in industrialized nations, the results have not been conclusive. It is not really clear, for example, at what age group (and what jobs) one should not be performing a certain job. Is there a difference across different muscle groups? Guidelines and data base are not widely available, and lacking particularly in developing countries such as Indonesia. Studies in this area are important, especially since the relationship between muscle strength and aging is specific for each population [8].

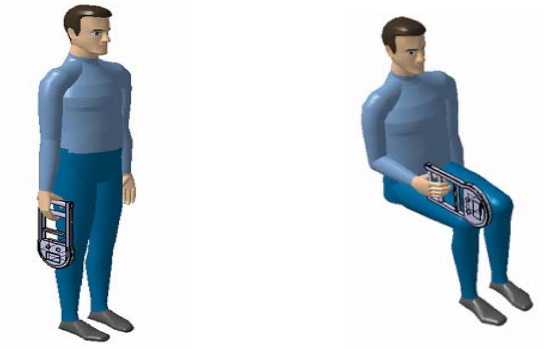
Research on biomechanics in Indonesia have typically only addressed working postures and the practical issues of manual material handling [9-15]. None, however, has studied muscle strength as it relates to gender or age factors. It is not known, for example, what age group has the maximum ability to exert muscle force. It is not clear, if there are differences across muscle groups. While older age is characterized by strength decline, the quantitative data for each age group are still lacking. Furthermore, female workers have often been marginally recruited, but it is not known if they actually have the required strength needed for jobs done male workers.

This study aimed at describing the relationship between age, gender, and muscle strength for Indonesian workers. Both hand grip and lower back strength have been chosen, since they are representative of general body strength, and are closely related to many physical industrial activities. It is expected that findings of this study could be used as a basis and guideline for worker selection and, more importantly, for designing industrial tasks and hand tools [16-18].

2. Methods

Ninety-six (48 males and 48 females) industrial workers were recruited in this study. Participation was solicited via flyers distributed in a number of places in the city of Bandung. Their ages were between 18 and 65 years old. All of the participants provided their consent, and were paid for their time. During their first visit to the laboratory, anthropometric and demographic data were obtained and the experimental procedures were explained. This study had been approved by the university ethical committee.

Handgrip measurements (using hand dynamometer, T.K.K 5101) were performed in standing and seated positions [19-21]. In the standing posture, the participants held the dynamometer with straight arm, whereas in the seated position, the arm was flexed 90° (Figure 1). Each participant was required to exert



(a) (b)

Figure 1. (a) Handgrip Strength in Standing Position (b) Handgrip Strength in Sitting Position

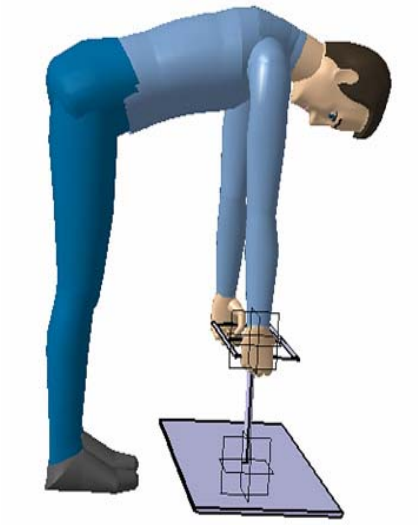


Figure 2. How to Use Force Transducer

maximal force for three times (3 minute-rest in between), and the greatest force was recorded.

For the lower back, strength measurements were done by employing Force Transducer SBO 500 equiped with a digital read out (DBM 3). Participants stood with the legs straight, and the lower back flexed forward at about 90°. With their arms straight holding the handle (Figure 2), they were asked to pull the handle up using the back muscle as hard as they could. Three trials were given, and the greatest force of the three was recorded.

All of the data were subjected to Kolmogorov-smirnov [22] test for normality. Paired t-test were employed to test the effect of age on muscle strength, whereas independent t-test were used in determining gender effect. Statistical analysis was done by using SPSS, with $p < 0.05$ used as a criterion for significance [23].

3. Results and Discussion

As previously mentioned, strength measurements were done in three different postures (handgrip-standing, handgrip-seated, and lower back-flexed). Results of the experiment are shown and discussed below.

Handgrip strength in standing position. Participant handgrip strength data show an increasing pattern up to around 36 years of age, and a declining pattern (though not constantly) afterwards (Figure 3). Female handgrip data were generally lower than the males. Handgrip strength of men varied, with an increasing value prior to 30 years of age, and a decline after 40 years (though at varying grades). Similarly, variability of females hand grip strengh also varied. It can be seen that the hand grip strength at the age of 55 years and over is lower than young ages.

For the male participant, the mean greatest strength was around 41 N (36-40 years old), while for the females this figure was 38.4 N (36-40 years old). Based on the data handgrip strength of the subject in standing position decreased significantly (32%, $p < 0.05$) at age 41-45 years and 21% at age 51-55 years. At the age of 55 or older, this tended to rise and then fall gradually. A maximum decline of 32% was found when comparing the maximum figures with the minimum values. Handgrip strength in standing position was about 34.5 N for male subjects and 21.1 N for female subjects. Female participants obviously exerted less force (65%) than the males ($p < 0.05$). Overall, handgrip strength was 10-52.6 N with a mean strength of 28 N (Table 1).

Handgrip strength in sitting position. Participant handgrip strength data show an increasing pattern up to around 36 years of age, and a declining pattern (though not constantly) afterwards (Figure 4). Female handgrip data were lower than those of males'. Handgrip strength of the male participants increased prior 30 years old, and a decline after 40 years old. Large data variability was also shown for the female handgrip strength.

The greatest strength for the male participants was around 41 N (age 36-40), and the peak for the females was roughly 38 N (age 36-40). Thus, a slight difference

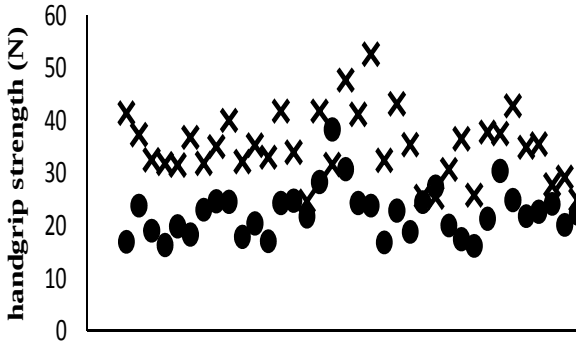


Figure 3. Male and Female Handgrip Strength in Standing Position ● Female, ✕ Male

Table 1. Handgrip Strength in Standing Position

Age	Male		Female	
	Mean (N)	Standard Deviation	Mean (N)	Standard Deviation
≤20	37.1	4.4	34.8	3.5
21-25	33.4	2.4	29.7	4.3
26-30	36.5	4.2	34.3	4.6
31-35	35.9	9.0	32.4	9.0
36-40	40.9	7.8	38.4	6.7
41-45	28.8	4.8	25.5	5.1
46-50	37.7	3.1	32.7	4.4
51-55	28.8	4.6	26.5	7.1
56-60	34.2	7.7	32.3	6.8
61-65	36.0	4.8	33.4	4.3

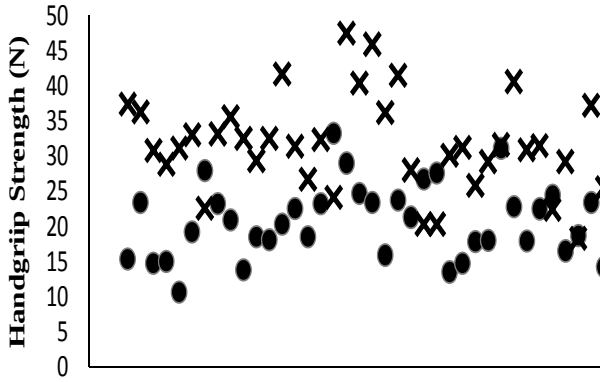


Figure 4. Male and Female Handgrip Strength in Sitting Position ● Female, ✕ Male

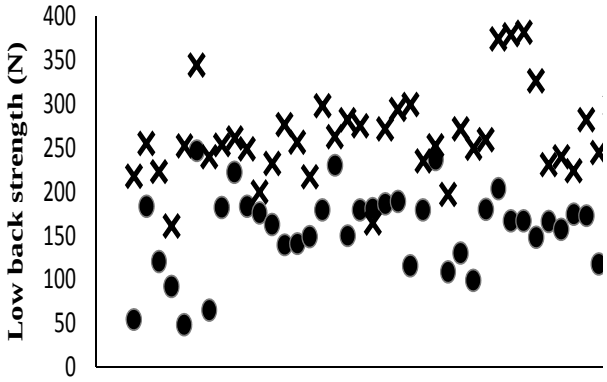


Figure 5. Lower Back Strength of Male and Female ● Female, ✕ Male

Table 2. Handgrip Strength in Sitting Position

Age	Male		Female	
	Mean (N)	Standard Deviation	Mean (N)	Standard Deviation
≤20	34.83	3.54	17.80	4.86
21-25	29.73	4.36	19.18	6.77
26-30	34.32	4.69	18.32	2.79
31-35	32.40	9.09	25.26	5.78
36-40	38.40	6.76	21.76	3.57
41-45	25.54	5.19	20.04	6.69
46-50	32.76	4.49	22.44	5.37
51-55	26.52	7.19	19.42	4.40
56-60	32.34	6.80	18.14	8.16
61-65	33.40	4.36	13.64	3.14

Table 3. Lower Back Strength

Age	Male		Female	
	Mean (N)	Standard Deviation	Mean (N)	Standard Deviation
≤20	231.1	20.1	118.4	64.4
21-25	249.4	65.0	126.2	84.5
26-30	282.8	11.3	175.9	30.4
31-35	262.2	30.6	168.9	36.7
36-40	259.9	55.1	169.0	30.7
41-45	239.9	27.9	149.8	57.2
46-50	427.0	21.3	172.3	20.3
51-55	243.4	22.6	156.8	23.3
56-60	268.9	19.7	163.1	23.9
61-65	323.6	14.6	122.7	27.9

existed with respect to the age group. It should be noted that maximum strength for the male participants (in both positions) did not seem to differ. For the females, such a difference might exist. Similar to the data collected in the standing posture, the female participants had lower strength (15%, $p < 0.05$) compared to the males. Across participants, handgrip strength was 11-47 N, with a mean of 26 N. The handgrip strength in sitting position was 31.9N for male subjects and 19.6 N for female subjects (Table 2).

Lower back strength. Figure 5 shows lower back strength for the participants in this study. The peak values as well as the pattern were not as clear as the handgrip data. Variability of the data also seemed greater for the lower back strength.

Maximum strength of 427 N (46-50 years old) was observed for the male participants, while the corresponding figure was 175 N (26-30 years old) for the females. Thus, for the peak, there was a difference in age group. For both genders, lowest strength was found in the group of less than 20 years of age. This was the opposite with respect to the lowest figures obtained during handgrip tests. Across genders and ages, mean lower back strength was 280 N. The lower back strength for male subjects was 283 N and 153 N for female subjects.

Discussion. The results indicated that there were relationships between age, gender, and muscle strength, although patterns of these relationships may not necessarily consistent. It is worth to note that male participants were generally able to exert larger forces than their female counterparts. Differences existed, in which, the females exerted 20-30% less force.

Pattern of handgrip and lower back muscle strength varied. This study demonstrated that handgrip strength for both extreme groups (≤20 vs. 61-65 years) was similar. During sitting posture, however, differences existed between the two age groups. For the male, the younger group exhibited 50% lower strength, while for

the female this figure was around 23% (Table 1and 2). As for the lower back protocol, the younger (≤20 years old) male participants exhibited 30% lower values than the older group (61-65 years old) (see Table 3). For the female participants, no differences seemed to exist when comparing the two age group.

The study by Backman *et al*. [24] measured handgrip srength that involved Swedish samples. Their data indicated muscle strength that was approximately 20% greater than the Indonesian samples in the present study. It should be noted, however, their study did not mention what posture was adopted. Zhongliang [25] demonstrated that static muscle strength at age 19-29 years is 135% higher than those at age 55-65 years. The lowest handgrip muscle strength is at age 60-70 years for both genders. These data are somewhat different from data in the current study. For the Indonesian sample (this study), the older group may have greater muscle strength. This is particularly true for the lower back protocol.

The decline in muscle strength has been discussed in the literature [6]. Frontera *et al*. [6] noted that body metabolisms are responsible for the declining strength, as one gets old, especially after the growth period. At older age the bones loss fluids and increasingly fragile. There is kyphosis, and the movement of hips, knee, and fingers was limited. The joints swell and become stiff. In addition, tendons constrict and sclerosis occur, atrophy of muscle fiber (fiber muscles shrank) resulting in slow body movement, muscle cramps, and tremor. Atrophic changes can affect all tissues and organs, as well as reduction of muscle fiber resulting in the decrease of muscle function. Furthermore, there is also loss of muscle mass accompanied by loss of muscle strength and dexterity [4].

In old age there is also degeneration of neurons that causes loose and weak muscles. Muscle diminution describes neuron shrinkage and death of neurons ultimately. Motor neuron disease found in the spinal cord is usually experienced by people between the ages of 50-70 years who have weak motor neurons [26].

It is worth to mention that strength decline could also be due to work exposure. Schibye [21] explained that handgrip strength does decline with age. The study showed that participants with monotonous and repetitive handwork at older age have handgrip strength lower than who do not work with hand. This is not seen in younger people. This may indicates that there is the decrease of strength in participants if their jobs were repetitive and monotonous. It is not known, however, how much this factor influenced results in our study.

With respect to gender differences, Maughan [27] explained that there are differences in muscle strength of male and female. Male are physically stronger than female because of differences in growth hormone in male and female. It is also influenced by the content of chromosomes possessed by male and female. Humans have 23 chromosomes, and each has two chromosomes bringing the total to 46 chromosomes. One group of the chromosomes is obtained from the father and other group chromosome is obtained from the mother. One of the 23 chromosomes will distinguish the sex of male and female. Female carry two X chromosomes becomes XX and male carry one X chromosome and one Y chromosome to be XY. The difference of the chromosome becomes one of the causes of differences in strength between male and female.

Despite the decline of strength due to aging, there are ways to minimize the effect. Previous studies, for example, indicated that muscle strength can be increased by 20% with exercise [28]. Workers who require muscle strength capability can perform muscle strength exercise to increase their muscle strength. The advantage of muscle strength exercise are enhancing metabolism, decreasing blood pressure in long term, preventing the decline of bones, and maintaining muscle mass. Substantial increase in muscle strength can also be obtained by maximal exercise [29].

A number of implications for industry are very relevant to the findings of the study. Currently, no data base has existed that clearly indicates strength of different muscular groups. In contrast, from this study we now know that strength of the lower back for females was less than 200 N. For manual material handling jobs, it can, therefore, be determined if gender selection is important, and if workers should be selected based on their age. Note that the National Institute of Occupational Safety and Health (NIOSH) in the US has determined 225 N as a maximum limit of safe handling [30]. This figure could be revised if we consider the data obtained using Indonesian samples.

Similarly, we also know that the majority of participants (both males and females) were able to exert hand grip force within 15.0 N. This implies that any job involving hand activities should be designed in such a way that requires much less than 15.0 N. While the exact figures may still be debated, this study clearly demonstrates that human muscle strength data (and the associated factors such as age or gender) have to be collected, and evaluated with respect to physical job requirements. Such an evaluation (for product design) has been investigated by Voorbij and Steenbekeers [16].

It should be noted that this study is not without limitations. First, data on human factors tend to have large variability. Such is the case in this study. Getting a much larger number of participants could improve the strength of this study. Associations and correlations

could be more meaningful. Still, as an initial effort, contribution of this study should not be marginalized. Second, the samples recruited were not necessarily representative of workers in all sectors. This could certainly affect strength data, and stratified sampling could improve the representativeness of the workers. Lastly, a few inherent factors (levels of regular exercise, demographic, or even cultural) could influence the amount of muscle force exerted. Hence, it was possible that differences were not merely due to the effects of age or gender. Consequently, further investigations are still needed with the expectations that they will provide a much clearer description of age, gender, and their relationships with muscular strength.

4. Conclusion

The aim of this research was to describe the relationship between age, gender, and muscle strength. The results indicated that there was a tendency for decreasing muscle strength as an individual got older. This phenomenon was found for both genders, but the patterns were not necessarily consistent, and a difference was found between strength protocols. For the handgrip (standing position), peak muscle strength was observed at the age of 36-40 years old, regardless of gender. In seated posture, the peak was found at the 36-40 age bracket (males) and 31-35 age bracket (females). For the lower back, the peak was found at 46-50 years of age (males) and 26-30 years of age (females). This study also found that older age does not necessarily exhibit lower strength compared to the younger age. This study had a number of limitations (such as the number of samples), that potentially result in large data variability. Consistent patterns were not obtained, and conclusions cannot be drawn easily. This study, however, demonstrated clear differences in muscle strength between genders, with females showing 20-30% less strength. Results of this study could be used as a rough guideline in determining match between work demands and human capabilty. Further research is warranted, that studies relationships between age, gender, and human physical capabilities.

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