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Forward head posture affects the static and dynamic balance of bank workers

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ABSTRACT

Background: Forward head posture (FHP) on bank workers who work a lot of time in front ofcomputer can cause balance problems due to anatomical changes in the neck. This can disrupt work productivity when further complaints occur. This research aimed to determine the relationship between FHP with static and dynamic balance among computer-using bank workers in Denpasar City.

Methods: The study was an analytical observational study with a cross-sectional design. The sampling method used was purposive sampling. The sample size was 68 people determined by the Lemeshow method. Photogrammetry method used to assess CVA and determine FHP criteria. Single Leg Stance Test (SLS) was used to assess static balance, and the Star Excursion Balance Test (SEBT) was used to assess dynamic balance. The inclusion criteria were bank workers that had proven with an employee card, were 25-50 years of age, working with a computer for around 1-4 hours daily or more, had a minimum of one year of service as an employee, willing to be a subject, and filled out informed consent as the approval. Exclusion criteria included subjects having a history of musculoskeletal disorders.

Results: Spearman rho analysis shows significant correlations between FHP with static and dynamic balance respectively, r = 0.817 and r =0.500 (*p*-values= 0.000).

Conclusion: Based on the result, there are linear strong and moderate significance correlations between forward head posture with static and dynamic balance respectively on computer-using bank workers in Denpasar city. Posture education and stretching exercises through ergonomics training by the institution should be conducted to minimize the ongoing effects of FHP and prevent decreased work productivity.

Keywords: Computer worker, dynamic balance, forward head posture, static balance.
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INTRODUCTION

Denpasar City is Bali's capital and the center of various activities, such as government, education, and the economy. The economic development and growth of a region is determined by the conditions of the formal and informal sectors. The formal sector is run by formal workers and the informal sector is run by informal workers.[1] Based on the Bali Province Central Statistics Agency, 60.9% of the working population in Denpasar are formal workers and the rest are informal workers.[2] A preliminary study conducted found that the formal worker population had musculoskeletal complaints in the upper neck (n=18), lower neck (n=14), left shoulder (n=14), right shoulder (n=11), back (n=15), and waist (n=17).[3] Those who work in the formal sector are often associated with office work.[4] The widespread use of computers in offices has led to an increase in the daily time a person spends using a computer. This can be accompanied by changes in poor body posture and resultant musculoskeletal complaints.[5,6] A person who works in front of a computer with the wrong posture, leaning neck forward or bending his neck when looking at the monitor screen, and doing this repeatedly for an average work duration of more than 1 - 4 hours per day for 1 year or more will cause the head to move forward, resulting in an excessive anterior curve of the lower cervical and an excessive posterior curve of the upper thoracic; This condition is known as Forward Head Posture.[7]

Forward Head Posture or FHP is a common type of postural disorder and is usually described by a shift in the center of gravity of the head in an anterosuperior direction away from the vertical line of the body's center of gravity. This can increase the burden on the neck and result in other health complaints.[8] Normally, the position of the head, namely the ears and shoulders, is in the same line.[9] Measuring angles between anatomical landmarks is a reliable method for evaluating head and neck posture. Several objective approaches have been known to measure FHP, such as measuring the craniovertebral angle, head tilt angle, and head position angle. The craniovertebral angle (CVA) measurement method is the most used method. This measurement is carried out by calculating the angle between the horizontal line of the shoulder which is parallel to the spinous process of C7 and the line of the tragus of the ear which is parallel to C7.[6,8] There is no clear cut-off threshold for identifying

FHP, but a degree of CVA measurement of less than 50° can be a good indicator for FHP.[9,10] FHP can reduce the sensation of joint movement and body balance. This is caused by anatomical changes in the neck which cause a shift in the center of gravity as one of the factors that influence balance.[11]

Balance is defined as a person's ability to react quickly and efficiently to maintain postural stability, and is a very important bio-motor component in carrying out daily life activities.[12] Balance is needed to maintain a static position and when moving from one position to another.[13] The risk of falls and musculoskeletal injuries increases when balance is disturbed. In more productive populations, this will affect productivity and expected work results because they have to lose work time to recover as a result of the complaints they experience.[14] Balance can be influenced by many factors, starting from the components of the sensory system (visual, vestibular, and somatosensory), central nervous system, musculoskeletal system, center of gravity, line of gravity, and base of support.[15] There are two types of balance, static and dynamic balance. Static balance is the ability to control balance to maintain a stable position at rest.[16] Meanwhile, dynamic balance is defined as the ability to move from one point to another while maintaining balance.[17] The Single Leg Stance (SLS) Test also known as the Standing Stork Test (SST) is a measuring tool that has been commonly used to assess a person's static balance ability. SLS can be used to see a person's risk of falling in addition to assessing the subject's neurological and musculoskeletal status.[18] In measuring dynamic balance, the Star Excursion Balance Test (SEBT) was chosen because it is a reliable and responsive measuring tool. Researchers chose to simplify the measurements with the Modified Star Excursion Balance Test (mSEBT) without reducing the essence of the SEBT measurement.[19]

The place where the research was carried out was one of the banks in Denpasar City. According to initial observations, activities within the Bank consist of doing office work with risks of FHP, with long working duration, and being in a static position for some time in front of the computer. This is supported by the findings in previous research by Nejati et al (2014), of 101 office workers who used computers, more than half of the workers (61.3%) experienced FHP.[20] With balance, research by Wijianto, Dewangga, and Batubara (2019) found a significant correlation between FHP in computer users and postural balance.[13] In contrast, Karajgi et al (2015) found no statistically significant effect of forward head posture on individual balance in the Modified Clinical Test for sensory interaction with balance.[21] New studies conducted on similar topics can consider several things to improve the quality of research, including standardized FHP measurement methods, diagnostic criteria for FHP, controlling confounding variables, namely age, type of work, and so on, and paying attention to other changes in individuals with FHP, such as vestibular function, nerve function, and musculoskeletal function. Based on the explanation regarding FHP above, it is suspected that FHP can affect balance and increase the risk of injury and thus impact work productivity. Research is needed to determine the relationship between Forward Head Posture and static balance and dynamic balance in computer-using bank workers in Bali.

METHODS

One of the banks in Bali, Indonesia was chosen as the study location. The study was an analytical observational study with a cross-sectional design conducted in March 2024 based on the Bank's availability. The sampling method used was purposive sampling. The sample size was 68 people obtained through the Lemeshow method with a 20% estimated proportion, 10% sampling error, and 10% dropout criteria.[22] Inclusion criteria were working at the Bank proven with an employee card, being 25-50 years of age, working with a computer for around 1-4 hours daily or more, having a minimum of one year of service as an employee, willing to be a subject, and filled out informed consent as the approval. Exclusion criteria included subjects having a history of musculoskeletal disorders, especially in the lower extremities which could interfere with balance examination procedures and which were known through interviews by a physiotherapist, subjects with a history of neurological, vestibular or visual system disorders such as vertigo, hemianopsia, and nystagmus which were known through interviews by a physiotherapist. Subjects who refuse to comply with the measurement procedures will be excluded.

The photogrammetry method as a noninvasive postural evaluation technique was used to assess CVA and determine FHP criteria. With its reliability (ICC=0.81-0.87), this method has been used multiple times in other studies as the easiest and simplest way to measure CVA.[23] Single Leg Stance (SLS) was used to assess the static balance of the subjects. SLS has a high sensitivity and specificity (sensitivity 0.63; specificity 0.60). The test-retest reliability of the SLS is ranging from fair (ICC = 0.60) to high (ICC > 0.90). The SLS was done with subjects instructed to stand with their feet close together, hand placed on the waist, and lift one of their feet at 45° hip flexion, time starts recorded when the foot leaves the ground until the subject lost balance (lifted foot touches the ground or hand leaves the waist). A mean of three trials was used as the final result.[24]

The Star Excursion Balance Test (SEBT) was used to assess dynamic balance. The intra-class correlation coefficients range from 0.67-0.87 with fair to excellent intra-rater reliability (ICC=0.67-0.97). A simpler and easier procedure of the SEBT was used with three lines, the anterior (ANT), posteromedial (PM), and posterolateral (PL). This simplification of the procedure is called the modified Star Excursion Balance Test (mSEBT). Started with standing on the axis of the three lines and one foot lifted from the ground, the subject was then instructed to use the lifted foot to reach the farthest length of each line. Subjects declared failed and did a retake if they used their hands to maintain balance, the heel of the supporting foot was lifted, or the body weight shifted and dropped on the reaching foot.[19]

Research began with obtaining research permits and briefing with colleagues and a physiotherapist to equalize perceptions. The researcher explained the benefits and objectives of the study followed by respondents filling out informed consent and personal data questionnaire individually. The Physiotherapist

helping this study conducted a short interview to assess the subject's history of musculoskeletal injury, and visual, vestibular, or neurological disorders. Researchers then assessed the static balance, took pictures of the subjects' posture, and assessed the dynamic balance of the subjects. The researcher collected the data and used Kinovea Software to measure CVA objectively. Data obtained was then processed, and univariate analysis was carried out for each variable followed by bivariate analysis with Spearman Rho. This study received approval from the Udayana University, Faculty of Medicine's ethical committee under protocol number 2023.01.1.1250. Informed agreement from the respondents to the survey was also provided, which approved the use of sampling.

RESULTS

This research was an observational analytical study with a cross-sectional approach carried out on computer-using bank workers at a national bank in Bali, Indonesia. Research subjects were selected if they passed the inclusion, exclusion and dropout criteria determined by the researcher. Furthermore, the subject characteristics based on gender, age, length of service, duration of work, and duration of computer use are described in Table 1.

Based on Table 1, the frequency distribution of subject characteristics described 68 subjects consisting of 48 men (70.6%) and 20 women (29.4%). The age group of the subjects was divided into late adolescents (n=4), early adults (n=31), late adults (n=20), and early elderly (n=13), with a mean age of 36.29±7.93 years. The table above shows the frequency of subject characteristics based on the duration of work per day, years of service, and the duration of the subject's computer use at work. A total of 49 subjects worked more than 8 hours per day and the rest (n=19) worked less or equal to 8 hours per day. The mean duration of work per day of the subjects was found to be 9.31 ± 1.12 hours. Subjects in this study had an average year of service of 11.79 ± 7.71 years. A total of 32 people have worked as bank employees for more than 10 years, 24 people have worked for 6-10 years, and 12 other people have worked for less than 6 years. It is also known that more than half of the computer-using employees who were subjects spent more than 4 hours in front of the computer (n=66; 97.1%), and the rest used the computer for 2-4 hours (n=2; 2.9%). The average time the subjects spent working in front of the computer was 7.74 ± 1.51 hours.

Table 1. Characteristics of the subjects

Variable	Frequency (n)	Mean ± SD	Percentage (%)
Sex			
Men	48		70.6
Women	20		29.4
Age, years old			
17-25	4		5.9
26-35	31	36.29±7.93	45.6
36-45	20		29.4
46-55	13		19.1
Work Duration per Day			
≤ 8 Hours	19	9.31±1.12	27.9
> 8 Hours	49		72.1
Years of Service			
< 6 Years	12		17.6
6-10 Years	24	11.79±7.71	35.3
> 10 Years	32		47.1
Duration of Using Computer per Day			
< 2 Hours			
2-4 Hours	2	7.74±1.51	2.9
> 4 Hours	66		97.1

Table 2. Frequency distribution of the forward head posture (FHP)

Variable	Frequency (n)	Mean ± SD	Percentage (%)
FHP			
FHP	45	49.81±4.40	66.2
Non FHP	23		33.8

Table 3. Static and dynamic balance results

Variable	Minimum Value	Maximum Value	Mean ± SD
Static Balance, second			
Single Leg Stance	10	82	42.25±18.17
Dynamic Balance, (%)			
Star Excursion Balance Test	47.31	78.67	64.33±7.21

Table 4. The correlation between forward head posture (FHP), static- and dynamic-balance

Variable	Correlation	*p*-value
FHP with Static Balance	0.817	0.000
FHP with Dynamic Balance	0.500	0.000

Table 2 describes the frequency of subject characteristics based on the occurrence of FHP in this study. It was found that more than half of the subjects had FHP conditions through the CVA angle measurements and angle analysis using the Kinovea software. The mean and standard deviation of the CVA angle in this study was 49.81 ± 4.40 degrees. Following in Figure 1 is an example of the determination between groups with FHP and those without FHP.

In table 3, it is known that the mean and standard deviation of the Single Leg Stance (SLS) measurement results was

Figure 1. Subject with forward head posture (FHP) (left) and subject non-FHP (right) (Source: Personal Documentation).

42.25 ± 18.17 seconds. The mean and standard deviation for the Star Excursion Balance Test (SEBT) measurements was 64.33 ± 7.21 percent. The minimum value for SLS measurement results was 10 seconds and the maximum value obtained was 82 seconds. Meanwhile for SEBT, the minimum score obtained was 47.31% and the maximum score obtained was 78.67%. The Spearman rho test was used to test the research hypothesis: there is a relationship between forward head posture and static balance in bank workers who use computers in Bali, there is a relationship between forward head posture and dynamic balance in computer-using bank workers in Bali.

Based on table 4, this research demonstrated the significance of both FHP with static balance and static dynamic balance in bank workers who use computers in Bali (p-value = 0.000; $p < 0.05$). The r-values = 0.817 and r = 0.500 respectively showed a strong relationship between FHP and static balance and a fair relationship between FHP and static balance. Based on Table 4, there was a positive correlation between the two variables. It shows that the more a computer-using bank worker has an FHP, the lower their balance, both static and dynamic separately.

DISCUSSION

This research was a cross-sectional analytical study with a sample size of 68 obtained through Lemeshow formula calculations. Of the 75 subjects that researchers were able to reach over the two days of sampling, 72 subjects met the inclusion criteria, and 4 subjects were subsequently excluded. With 68 subjects passed the screening procedure, it is known that the subjects consisted of 48 men (70.6%) and 20 women (29.4%) with an age range of 25-50 years. Women have 2–3° greater cervical flexion ability than men often related to psychosocial problems such as stress (25). In research conducted on adolescent populations, the incidence of FHP was more frequently identified in female subjects (26).

The duration of work per day is divided into groups who work standard hours less than or equal to 8 hours per day, and groups who work more than 8 hours per day. A total of 49 subjects worked more than 8 hours per day and the remaining 19 subjects worked less or equal to 8 hours per day. The mean duration of work per day of the subjects was found to be 9.31 ± 1.12 hours. Bank X's overall workload is measured using the Work Load Analysis system annually. Variations in the distribution of work duration between employees are assumed to be related to differences in the type of work and functionary positions within the institution.

The subjects of the study were distributed in the age groups of late adolescence (n=4), early adulthood (n=31), late adulthood (n=20), and early elderly (n=13) according to real data found in the field. The subjects in this study had a mean age of 36.29 ± 7.93 years and a working period of 11.79 ± 7.71 years. A total of 32 people have worked as bank employees for more than 10 years, 24 people have worked for 6-10 years, and 12 other people have worked for less than 6 years. The bank where the research was conducted has been established for more than half a century, therefore several employees have spent time working under the agency for a long period, up to more than 10 years, since their late teens or early adulthood following established recruitment regulations.

More than half of the computer-using employees spent more than 4 hours in front of the computer (n=66; 97.1%), and the rest used the computer for 2-4 hours (n=2; 2.9%). Activities within Bank X started to transform digitally and used electronic media, especially computers available in the office. This certainly increases the time of using computers by an average of 7.74 ± 1.51 hours per day.

Based on the findings, 45 of the 68 bank worker subjects who used computers had FHP with a CVA angle below 50°, and the remaining 23 subjects did not have FHP. The mean and standard deviation of the CVA angle in this study was 49.81 ± 4.40 degrees. Another study has found similar findings regarding the incidence of FHP in computer user populations. Compared with the population who do not have FHP, a higher percentage of computer users with FHP was found in this study (92.9%) (27).

The minimum value obtained by a subject in the Single Leg Stance was 10 seconds, with the maximum value obtained by one subject reaching 82 seconds. The average static balance of all the subjects was 42.25 ± 18.17 seconds. On the other hand, the results of the Star Excursion Balance Test were displayed in percent units after calculating the normative COMP score from the measurements taken. The minimum and maximum values obtained by the subject were 47.31% and 78.67% respectively. The mean normCOMP score of the subjects was 64.33 ± 7.21%.

Through hypothesis testing carried out using the Spearman Rho test, a significant correlation was obtained in the relationship between FHP and static balance and dynamic balance, with a

similar *p*-value (p=0.000). The r value obtained through hypothesis testing is positive for the two relationship variables studied. A strong correlation was found for the relationship between FHP and static balance (r = 0.817), as well as a fairly strong relationship for FHP with static balance (r = 0.500). These findings prove that bank workers who use computers with FHP will have lower static balance values. In addition, a bank worker who uses a computer and has an FHP is proven to have a lower dynamic balance value.

Research on FHP and balance is increasingly becoming more widespread in the elderly population. This is based on a theory that explains the decline in overall body function which worsens the condition of FHP in the elderly and has an impact on worsening balance. However, the research trend on this topic is starting to expand and explore other risk factors that influence the occurrence of FHP, one of which is the type of work or habits following the relationship between FHP on balance.

Research proving the relationship between FHP and balance in computer-using bank workers is very limited and has never been conducted before. However, research on populations with different age ranges, different places of work, or different uses of electronic media has been conducted on this topic.

The results of these findings show a significant correlation between FHP and static balance and between FHP and dynamic balance. In line with previous findings by Lee (2016) regarding the influence of FHP on individual static and dynamic balance. This research was a case-control study that compares subjects with FHP and those without FHP. The research found that there was a significant relationship between FHP and static balance, but not with dynamic balance. Although the results of hypothesis testing on dynamic balance are not in line with the findings in this study, the study explained during dynamic balance measurements there was an increase in activity of the core postural muscles causing posture to be maintained better.[8] Another study that found contrasting results from the study was a case-control study by Karajgi (2015) regarding FHP and its relationship with balance. In this study, an insignificant relationship was found between FHP and dynamic balance, apart from a higher mean balance score in the FHP group compared to the non-FHP group.[21]

In a population that has a similar type of work (using computers), research by Wijianto and Batubara (2019) strengthens this research. A significant correlation was found between FHP and workers' dynamic balance (p=0.000; r=-0.784).[13] Another case-control study that is in line with the researchers' findings is research by Ahmadipoor et al (2022), the study contained an FHP group with a mean age of 36.65 ± 4.11 years and a mean CVA angle of 46.18 ± 1.55 degrees. In the control group, the mean age of the subjects was 37.15 ± 4.8 years with a mean CVA angle of 53.34 ± 1.88 degrees. Through hypothesis testing, significant results were found regarding the relationship between FHP and dynamic balance.[28]

Other research that is in line with the findings of this research is by Puspitasari (2018) with fair significant findings on the relationship between FHP and static balance (p=0.004; r=-0.310). Followed by Tawakkalni (2017) regarding the relationship between FHP and dynamic balance was proven to be significant with a value of p=0.001. Despite the parallel findings of the two researches, these two studies were conducted on different populations and using other electronic media (cell phones).[14,29]

In FHP, anatomical change occurs in the nape of the neck and disrupts a person's balance. This is based on a change in one of the balance factors and causes an increase in efforts to maintain body balance. Balance is built on several constituent factors including centre of gravity (COG), line of gravity (LOG), and base of support (BOS). The FHP condition causes changes in the COG and a shift of this point in the anterosuperior direction away from the individual LOG vertical line. Efforts to balance the body require the COG to always be relatively above the feet. A person is at risk of falling and causing musculoskeletal disorders when the COG moves beyond the position of the foot.[30] It will be risky, especially for bank workers who use computers because their productivity and expectations of work achievement are disrupted.[14]

Apart from affecting balance, other research explains how FHP is related to musculoskeletal complaints that can occur, especially in the neck area. In the FHP condition, there is a significant decrease in the activity of the neck muscles including the Middle Trapezius, Splenii, and Sternocleidomastoid through measurements using Electromyography (EMG).[5] In previous research by Nejati et al (2015) conducted on a population of office workers, it was found that more than half of 101 office workers who used computers experienced neck or neck pain (n=55).[6] Other research, in the form of a preliminary study conducted by researchers on formal workers, found that the large number of uses of computers at work was known through researchers' observations. The workers had musculoskeletal complaints in the upper neck (n=18), lower neck (n=14), left shoulder (n=14), right shoulder (n=11), back (n=15), and waist (n=17).[3] Individuals who complain of neck or neck pain have significantly more FHP compared to individuals who do not have pain, especially in the adult population.[31]

The implication of this study is to enrich and support literature related to FHP on balance. Practically, this research has implications for the importance of educating better posture and stretching exercises while working at a computer, either through special training by the relevant agency or through individual awareness.

The strength of this research compared to previous research that raised similar topics in both FHP with static balance and FHP with dynamic balance is the researcher's ability to control confounding variables and potential sources of bias that could influence the findings. In the FHP variable, researchers can control the factors that influence the occurrence of FHP in individuals, including type of work, mass of work, and duration of work. Other factors such as age, gender, and BMI are believed to cause FHP, but with inconsistent findings from previous researchers, researchers decided not to control these variables.[7]

One study that discusses the correlation between Body Mass Index (BMI) and

FHP is by Noviati et al (2022). The research carried out found a significant relationship (p<0.0001) with a negative correlation value (r = -0.731) in a similar population who used computers, proving the significance of the correlation between BMI values above normal and CVA values below normal (50°) which is the FHP category.[32] Despite the significant findings from the two research variables, the mechanism of the relationship between high BMI values and low mean CVA is not clearly explained. Therefore, the researcher decided not to control this variable.

Efforts to minimize the occurrence of bias are also carried out similarly for the dependent variable, static and dynamic balance. Through exclusion criteria, researchers can screen potential subjects based on histories of nervous, vestibular, and visual system disorders that are believed to affect balance, followed by histories of musculoskeletal disorders in the lower extremities that can interfere with balance measurements. The history of vertigo, hemianopsia, and nystagmus known through interviews is an important variable that researchers consider because it influences balance. This is important because balance measurement results should based on the shift in a person's centre of gravity due to FHP.

Although researchers were able to control other variables that could potentially be biased in this research. The research used the photogrammetry method to measure the CVA angle. Regardless of the reliability of the chosen measuring instrument, photogrammetric techniques are certainly inferior to cervical radiological measurements. The radiological technique for measuring FHP is carried out by taking X-ray radiograph images of the lateral cervical region. Compared with photogrammetry techniques, radiograph techniques will provide clearer depictions of anatomical landmarks, more precise angle measurements, and better assessment of cervical curvature.

CONCLUSION

Through hypothesis testing, there was a significant correlation between forward head posture and static balance. A significant correlation was also found between Forward Head Posture and static balance. The two variables have a positive relationship, indicating that the more a computer-using bank worker has FHP, the lower the person's static and dynamic balance.

ETHICAL CLEARANCE

This study received approval from the College of Medicine's ethical committee, Universitas Udayana, under protocol number 2023.01.1.1250. Informed agreement from the respondents to the survey was also provided, which approved the use of sampling.

CONFLICT OF INTEREST

The author declares that there is no conflict of interest.

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AUTHOR CONTRIBUTIONS

GMW prepares study designs, collects data, processes data, and writes manuscripts. MHSN, NLNA, and NKAJA are directing data collection and revising the manuscript.

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