Principle of Medical Screening for Participation in Exercise in Residents in the Community

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Pre-participation medical screening is widely used to ensure against potential exercise-related risks. It is reported that the most common underlying cause of cardiac sudden death associated with exercise is coronary artery disease in the adult population. Therefore, the evaluation of coronary risk factors is essential in medical screening for the elderly. In the present study, more than 50% of elderly subjects had one or more coronary risk factors such as hypertension, hyperlipidemia and about 10% of elderly subjects had more than 2 risk factors. Some novel coronary risk factors, such as total plasma homocysteine, and high-sensitivity C-reactive protein, while proposed in the literature, has not had the risk potential significance in medical screening established. Risk stratification based on medical screening is needed to optimize the safety of exercise, and high risk subjects who have signs or symptoms suggestive of cardiovascular diseases, or any coronary risk factor, should undergo further evaluation. Since pre-participation medical screening cannot ensure safety of exercise completely, physical condition check on the day of exercise is effective to enhance safety of exercise. More efficient medical screening systems will be needed to cope with increasing numbers of participants in exercise.

Keywords: Elderly, coronary risk factors, safety of exercise

1. Introduction

Pre-participation medical screening aims to assess the physical condition of a subject in determining the advisability of exercise, and to create basic data to improve the safety of exercise (Anno, et al., 1998; Murayama, 1999; Sakamoto, 2000; Musha, 2002; Kawakubo, 2004). It has been noted that the morbidity of asymptomatic diseases is higher for middle-aged and elderly people than younger people. Therefore, pre-participation medical screening which is not dependent only on subjective symptoms is required.

While pre-participation medical screening is useful in improving the safety of exercise performed after, it is assumed that there is difference among individuals in terms of validity of assessment made by pre-participation medical screening. Thus, it seems important to conduct medical screening periodically in order to improve the safety of exercise, in addition to physical condition checks on the day of exercise.

In pre-participation medical screening conducted in local communities, the subjects are mainly middle-aged and elderly people including very elderly people aged 75 years and over. Given this fact, it is necessary to develop appropriate measures when conducting pre-participation medical screening in view of characteristics of middle-aged and elderly people. Moreover, since a large number of subjects go through pre-participation medical screening at one time in a local community, it is necessary to seek a way to create a system for efficient medical screening while securing the safety of exercise. With these considerations, the ideal way of pre-participation medical screening in a local community will be discussed.

2. Importance of pre-participation medical screening for middle-aged and elderly people

Exercise is useful in health maintenance and enhancement and it is well known that exercise is helpful in prevention and medical treatment of
lifestyle-related diseases including hypertension, hyperlipemia and diabetes mellitus. Contrarily, inappropriate, excessive or complicated exercise could damage physical health and is responsible for the onset of, or deterioration in myocardial infarction and cerebral vascular disorder. At worst, it could result in unfortunate sudden death. It means that exercise is a two-edged weapon for the health of human being.

Many were shocked when a Cameroonian football player died suddenly during an international soccer match in June, 2003. While the cause of death is still unknown, the fact that a professional player would unexpectedly die during exercise raises an alarm about the safety of exercise, despite the rarity of such cases.

The number of cardiac sudden death is estimated to be 50,000-70,000 per year in Japan, although the current status of sudden death is still not clearly known. As indicated in the Hisayama study (1961~1983), the frequency of sudden death accelerates in accordance with aging (Ueda, 1997). It is well known that sudden death is more frequent for males than females in younger people (Doyle, et al., 1976). However, the gender difference disappears in elderly people aged 70 years and over (Tokudome, et al., 1999). Thus, it is more important for elderly people regardless of gender than younger people to get pre-participation medical screening before starting exercise in order to exercise safely.

Among risks generated due to exercise, the worst is decidedly sudden death. According to a survey on the sudden death of elderly people during exercise in Japan (Musha, 1997), it has been reported that sudden death is frequent during Japanese croquet, golf and mountain climbing which are popular sports for middle-aged and elderly people. It is noticeable that the number of sudden death is highest in Japanese croquet which is considered to be safer for its low exercise intensity in particular, whereas it should not be surprising considering the high player population and lengthy playing time (Musha, 1997). Nevertheless, the fact that sudden death is experienced even during comparatively safe exercise shows again the importance of safety measures while doing exercise for middle-aged and elderly people.

The cause of sudden death is not always clearly understood. Regarding identifiable causes, cardiovascular diseases and functional disorders reportedly cover more than 70% of causes (Sakurai, et al., 1988). It is also reported that many cases of cardiac sudden death caused by exercise are due to coronary artery diseases in healthy middle-aged and elderly people (Chugh, et al., 2000).

In the latest statement from the American Heart Association, it is emphasized that the risk of sudden death and myocardial infarction onset caused due to exercise is higher for those without regular physical activity (Thompson, et al., 2003). This means that while the effect of exercise on health enhancement seems significant for those without regular physical activity, the risk of exercise is also great. Therefore, it is assumed that questioning on habitual physical activity is important in order to understanding the degree of risk in doing exercise.

Jouven, et al., (2005) investigated the risk factor of sudden death in 7,746 middle-aged males and reported that an increase in heart rate at rest, specifically 75/min and over, is an independent risk factor of sudden death besides the possession of coronary risk factors. Disorders in the balance of cardiac autonomic nerve function (decrease in cardiac parasympathetic nerve function, increase in sympathetic nerve function) may be related to an increase in heart rate. This is a phenomenon often observed in physical inactivity, which seems to be related to the increase in the risk rate of exercise-related sudden death for those who lack regular physical activity.

Moreover, pre-participation medical screening is necessary in middle-aged and elderly people especially for a number of reasons: With aging, those who have atherosclerotic diseases including coronary disease, which is considered to be the main causal disease of sudden death during exercise increase, and those who possess risk factors also increase. Coronary risk factors which are used to assess the tendency to be affected by coronary artery disease, as typified by myocardial infarction, include aging (45 years and over for male, 55 years and over for female), family history (myocardial infarction or sudden death of father or first-degree relative male before 55 years of age, or mother or first-degree relative female before 65 years of age), smoking, hypertension, hyperlipidemia and glucose intolerance (Kitabatake, et al., 2001). Figure 1 shows the typical coronary risk factors prevalence among the middle-aged and elderly subjects who spend independent daily lives in local communities solicited to participate in our research. Those with
apparent diseases and symptoms that may cause risk during exercise did not participate. As indicated in Figure 1, the frequency of coronary risk factors is high in middle-aged and elderly people, who have a high risk of developing atherosclerotic diseases. Among these subjects, there are many who do not seek medical attention and so the disease is neglected. This indicates that the risk of cardiac events is high for elderly people if they perform inappropriate or excessive exercise.

In addition, the distribution in numbers of possessing coronary risk factors in middle-aged and elderly people living in local communities was studied and shows that the number of combined carriers who have more than two coronary risk factors is few in middle-aged while about 10% of subjects are combined carriers in both younger and very elderly people (Figure 2). It is assumed that the risk degree increases as coronary risk factor prevalence becomes larger. The group of risk factors, that is, upper-body obesity, glucose intolerance, hypertriglyceridemia, and hypertension, is referred to as the "deadly qualtet" (Kaplan, 1989), which reportedly heightens the risk of developing coronary artery diseases significantly (Shimamoto, 2004).

In a recent study, it is reported that a high onset of coronal artery disease is observed even in subjects who do not have the established coronary risk factors identified so far (Ridker, 2003). In response, studies on new risk factors other than established risk factors are increasingly being conducted, and have identified elevated total homocysteine levels and C-reactive protein (CRP) levels as new risk factors (Ridker, 2003). An epidemiology study which targeted

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**Figure 1** Typical coronary risk factors prevalence in middle-aged and elderly people living in local communities
Subjects are 293 males (50 middle-aged under 65 years, 168 younger elderly 65-75 years old, 75 very elderly over 75 years) and 552 females (208 middle-aged, 259 younger elderly and 85 very elderly). The above chart shows the results by gender. Females above and males below.
Japanese, reported that the elevated plasma total homocysteine concentration is a risk factor in the onset of cerebral vascular disease (Iso, et al., 2004). However, there is still some debate over whether it is an independent risk factor in coronary artery disease. In our investigation on middle-aged and elderly people in local communities, the frequency of females who have hyperhomocysteinemia (more than 12 μmol/L of plasma total homocysteine concentration) was low regardless of age. In contrast, the frequency of morbidity increased in male with aging and about 20% of very elderly male over 75 years of age possessed this (Figure 1).

CRP is considered to be a marker reflecting chronic inflammation of atherosclerotic region and high CRP level is largely accepted as an independent risk factor in coronary artery diseases (Ridker, 2003). According to Ridker (2003), the risk of cardiovascular diseases increases when CRP’s blood level exceeds 0.55 mg/l, which may be a cut-off level of elevated CRP. When examining middle-aged and elderly people living in local communities it was observed that the elevated CRP prevalence increased with aging regardless of gender (Figure 1). It is notable that elevated CRP was identified in more than 40% of elderly people of both sexes. Given that plaque rupture at affected area reportedly involves the causing of the onset of coronary artery diseases which causes most cardiac events during exercise (van der Wal, et al., 1994), and that unstable plaque which is known to cause rupture has some relation to elevated CRP (Ridker, et al., 2002), elevated CRP can be considered to have a different significance in pre-participation medical screening from established risk factors. However, future investigations are required to determine whether this should be included as mandatory in pre-participation medical screening.

As mentioned above, sometimes elderly patients have so called asymptomatic diseases, in which they develop diseases without subjective symptoms. Even if they notice symptoms, they are sometimes not typical for the disease (Sharma, et al., 1987). Although patients without subjective symptoms are likely to be regarded as mild cases, it is not necessarily so. Figure 3 shows the case of a very elderly person (Ajisaka, et al., 2004). Finding of a high degree ST-segment depression, which is suggestive of severe myocardial ischemia, was observed in the exercise electrocardiogram, although chest symptoms were not apparent. No subjective symptoms during exercise indicate a lack of warning signs of exercise-related risk and increases the risk which may lead to cardiac events during exercise. Therefore, it is important to recognize the existence of such asymptomatic or atypical diseases and to address them properly when considering the safety of exercise.

Kondo, et al. (2001) examined risk factors in sudden death, examining 164,017 male workers in Japan. Results showed that systolic blood pressure increase (over 160 mmHg), low HDL cholesteremia, hyperuricacidemia, electrocardiographic abnormalities, liver dysfunction and proteinuria were significant as independent risk factors. While

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**Figure 2** Degree of frequency of coronary risk factors in middle-aged and elderly people in local communities
The degree of frequency of carrying more than 2 risk factors is higher in elderly people compared to middle-aged. Aging as coronary risk factor is omitted.
the mechanism of each factor relating to sudden death and the connection between sudden death and exercise are still not clear, it is important to receive medical attention from specialists when some abnormalities relating to not only coronary risk factors and heart disease but also liver/kidney disorders were found in pre-participation medical screening.

Luukinen, et al., (2003) examined cardiac sudden deaths of 915 elderly people aged 70 and older and results of multivariable analysis suggest that depressive symptom is an independent risk factor. Although it is not clear whether exercise has some involvement in the relation between depressive symptom and sudden death, it might be worthwhile to consider introducing a simple psychological testing in pre-participation medical screening.

3. Procedure of medical screening before starting exercise

As mentioned above, it is important to determine the risk degree of exercise through pre-participation medical screening in order to ensure the safety of exercise in middle-aged and elderly people. Specifically, subjective symptoms (existence of subjective symptoms accompanying exercise; chest pain, palpitations, shortness of breath etc.), family history (concerning to cardiac sudden death in particular), lifestyle habits (including regular physical activities), existence of risk factors of atherosclerotic diseases, medical attention and medication are to be assessed through medical inquiry or questionnaires. Furthermore, physical findings (blood pressure, heart rate, and auscultation and palpation) are screened and basic physiological/clinical examinations (electrocardiography, chest roentgenography, blood examination) are performed. Following such medical inquiries, physical findings, physical and clinical examinations, the degree of exercise-related risk can be judged.

For those with high risk and suspicion of heart diseases or respiratory diseases, close medical examination such as exercise testing is necessary. The recommendation of the Japanese Society of Clinical Sports Medicine encourages exercise testing before starting exercise as a general rule for male 40 years and older and for female 50 years and older (Murayama, 1999). However, this recommendation assumes participation in sports activities including complicated exercise. By contrast, the recommendation of the American College of Sports Medicine (1995) allows high-risk people without subjective symptoms to omit exercise testing when the planned exercise is light and under moderate degree. Nevertheless, in cases of hypertension and diabetes mellitus without full control or with complications, evaluations of exercise in terms of indication or contraindication and exercise testing should be performed in some medical facilities as

![Figure 3](http://www.soc.nii.ac.jp/jspe3/index.htm)
a general rule, as indicated in the recommendation of the Japan Medical Association (1996). In fact, sometimes systolic blood pressure elevates as high as 200 mmHg and over during light exercise in patients with hypertension even being treated.

Also, those with liver, kidney and other various diseases need to ensure that exercise will not worsen the clinical condition through conducting pre-participation medical screening.

4. Stratification of exercise-related risk

When a subject has no risk factor of atherosclerotic diseases except for aging (over 45 years of age for male and over 55 years of age for female according to the criteria of coronary risk factors), has no symptoms of illness and does not get medical treatment, the risk of exercise is low and the subject can be categorized as low risk. When a subject has any coronary risk factor, or has subjective symptoms such as chest pain and shortness of breath, which are strongly suspected of heart or respiratory disease, the risk of exercise increases and the subject is categorized as high risk. High risk subjects need to conduct close examinations such as exercise testing in order to be diagnosed of potential diseases as soon as possible. As mentioned earlier, a subject who has no habitual physical activities or has apparently low physical fitness should be included as a high risk subject.

5. Safety measures on the day of exercise-

Importance of physical condition check

Pre-participation medical screening before commencing exercise is useful to enhance safety of exercise being performed later, although there are individual differences in terms of validity of assessment. Therefore, it is important to conduct checks on physical condition prior to exercise in order to enhance safety of exercise.

Although how and why the Cameroonian soccer player mentioned earlier died suddenly is still not clear, a press reported that he was in poor physical condition with persistent diarrhea for several days and was playing in a hot climate which may have been contributing factors in his death.

Poor physical condition during the week before, and on the day of exercise is considered to be a high risk factor in making an accident more likely. A report on 60 sudden deaths while playing squash noted that some unusual subjective symptoms existed in 55 (91.7%) cases in the prior week (Northcote, et al., 1986). The Japanese Society of Clinical Sports Medicine recommends postponing exercise or seeking medical treatment at times of poor physical condition, based on a self-check table for participating exercise drafted by the Japan Sports Association (Murayama, 1999).

Table 1 shows a self-check table for elderly people with items on blood pressure added. Since hypertension morbidity is high in elderly people, it is necessary to ensure the latest blood pressure condition at home and medication on the day of exercise especially for those treated with medication.

Through this self-check, if exercise is abandoned due to poor physical condition, an accident can be prevented. In addition, the time of exercise is important. Circadian variation is observed in the occurrence of sudden death. The incidence rate of cardiac events is highest from 7 am to 11 am due to the instability of autonomic nervous balance (Muller, et al., 1987). Elderly people generally tend to prefer early morning walking and jogging. Golf also starts early in the morning. Thus adequate attention is necessary for those with higher risk. For those who have coronary risk factors in particular, it is worthwhile instructing to avoid exercise early in the morning on an empty stomach, and to adjust the time of exercise according to individual lifestyle habit.

6. Pre-participation medical screening in local communities

A cost-effectiveness perspective is important when assessing the availability of pre-participation medical screening. Our study did not adopt urinalysis and chest roentgenography as essential check items which are, however, included in the basic inspection items proposed by the Japanese Society of Clinical Sports Medicine (Murayama, 1999). Instead the study referred to physical checkup data. Therefore, blood examination, blood chemistry examination and electrocardiography were performed. The points of these medical examination based on health insurance were calculated to 622, and the cost amounted to 6,220 yen. Adding 700 points for exercise testing to this, the total cost amounted to 13,220 yen.

The cost-effectiveness of pre-participation medical screening is often assessed using cardiac
events as effect index in research abroad (Fuller, 2000). In this study, one subject among 175 who participated in our exercise class held in Tsukuba City, developed unstable angina and needed admission treatment through PTCA. However, the number of subjects was too small to assess the cost-effectiveness from cardiac events during exercise. There is another method to assess the cost-effectiveness of pre-participation medical screening by the cost for identifying physically unfit. Among the previously cited subjects, one subject because of renal dysfunction, one because of arrhythmogenic right ventricular dysplasia (estimated by electrocardiography findings and determined by close examination) and three because of atrial fibrillation were diagnosed as physically unfit in the general medical examination without conducting exercise testing. Therefore, the cost for identifying physically unfit was 175 subjects multiplied by 6,220 yen divided by 5 unfit participants leads to a sum of 217,700 yen. When the cost of exercise testing was added, since the findings of another three subjects were positive for myocardial ischemia, the cost for identifying physically unfit amounted to 289,188 yen. Considering the fact that there are more potential patients of coronary artery diseases in elderly people than younger people, the increase in the cost through adding exercise testing is comparatively low in terms of cost-effectiveness. The cost is evidently small compared to 39,309,000 yen calculated for 5,562 subjects of the National Sports Festival participants reported by Kawakubo (2002). This may be an important consideration in differences in health degree between ordinary middle-aged and elderly people and the National Sports Festival participants. Also it can be perceived that the results show the importance of pre-participation medical screening in middle-aged and elderly people. Given the fact that the number of subjects is small in this study and it has targeted healthy subjects who live independently, further researches into the cost-effectiveness of medical screening in healthy middle-aged and elderly people are necessary.

The number of participants in the medical screening conducted in local communities is often large and the screening often needs to be performed effectively in the short term. In our investigation, the rate of subjects who were diagnosed to be in high risk against exercise reached about 80% among middle-aged and over 90% among elderly people who were the majority of the subjects of pre-participation medical screening in local communities (Figure 4). However, the number of subjects diagnosed as abnormal through exercise testing was few among those categorized as high risk in the medical screening. As described in Bayes

Table 1  Self-check on the day of exercise

<table>
<thead>
<tr>
<th>Question</th>
<th>No</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you have a high temperature?</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Do you feel languid?</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Do you sleep well?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Do you have an appetite?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Do you have diarrhea?</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Do you have a headache or chest pain?</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Do you have any joint pain?</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Do you feel over worked?</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Do you have higher blood pressure than usual?</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Are you still recovering from the last exercise?</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Do you have the incentive to participate in today's exercise?</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>
Theorem, it is well known that diagnostic sensitivity to exercise testing is low when conducted in healthy people (Kawakubo, 2000). This study acknowledges this theory and suggests it is also applicable to middle-aged and elderly people among whom there are suggested to be comparatively many potential carriers of coronary artery diseases. If effectiveness is over prioritized, the accuracy of medical screening required for the primary role as a check for exercise safety decreases, while it may increase the risk of causing dangerous accidents during exercise. While the safety should be prioritized, it is important to conduct the screening safely and efficiently while considering the cost-effectiveness perspective outlined above.

Cooperation with local governments or medical associations is one way. Pre-participation medical screening could be replaced with the results of physical checkup and medical checkup conducted by local governments or medical institutions, because the assessment from the data of physical checkup was almost the same as that of our pre-participation medical screening. In this regard, there are two conditions. First, the data should be updated as far as possible. Our study requested physical checkup be conducted 6 months prior to pre-participation medical screening and we confirmed that 70% of subjects could utilize their data of physical checkup. However, there is no established evidence for a 6 month limit and further examination is required concerning the term of validity. Secondly, it is needed that no physical change should be observed between at physical checkup and at pre-participation medical screening.

Mutual trust is necessary in cooperating with local communities or medical institutions effectively. So it is important to provide local communities or medical institutions with the result of pre-participation medical screening. In cooperating with medical institutions, not only close examination of exercise testing but also emergency care when cardiac attack occurs during exercise is important. At the same time, variations in procedure and assessment accuracy among institutions should be reduced as the medical institutions should be sufficiently experienced and reliable. It is also necessary to discuss and determine the method of close examination such as exercise testing and assessment standards with those institutions, or to present such information beforehand. Similarly, it might be useful to present checklists of pre-participation medical screening for safety exercise at the medical checkup in medical institutions.

The second way to promote efficiency of
pre-participation medical screening is to review the criteria of high risk. As shown in Figure 1, the prevalence of coronary risk factors in elderly people is considerably high, and the majority of elderly people fall under the category of high risk based on the criteria (referred as the "old" criteria in Figure 4), in which those who have any coronary risk factor except for aging, subjective symptoms such as chest pain, or are observed to have any malfunction in pre-participation medical screening, are regarded to be in high degree of exercise-related risk and assessed as high risk. When there are many high-risk subjects, it is difficult to conduct exercise testing for all of them, so it is desirable to establish other feasible risk assessment method. The American College of Sports Medicine (1995) states that exercise testing before moderate intense exercise is unnecessary when there are no symptoms of cardiovascular, respiratory and metabolic diseases even with more than two coronary risk factors (the new criteria referred in Figure 4) (American College of Sports Medicine, 1995). As such, targets of exercise testing can be reduced drastically by about 10% in middle-aged people, about 20% in younger elderly people, and by about 25% in very elderly people through applying the new criteria (Figure 4).

Nevertheless, this new criteria also has some flaws. Firstly, there are patients with asymptomatic diseases. Although there has not been any epidemiologic study results in Japan, the prevalent rate of asymptomatic ischemic heart diseases corresponding to Cohn 1 type (Cohn, 1989) among healthy elderly people is only a few percent according to the reports presented in Europe and the United States. However, if the need for exercise testing is determined by subjective symptoms, asymptomatic subjects who have some exercise-related risk might be determined as safe. As mentioned previously, asymptomatic ischemic heart diseases are not always mild, so even moderate intensity exercise should not be regarded as safe. Secondly, the sensitivity of electrocardiography diagnosis is not always good. The sensitivity has been reported to be about 60%, although researchers suggest it is variable (Kawakubo, 2000). There is a more sensitive diagnostic method which is, however, not available for all the elderly people who do not have subjective symptoms because of cost-effectiveness. Effective solutions for these issues have yet to be found. Magnetic resonance imaging (MRI) may have the possibility to solve these issues when used more widely in future.

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