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Analysis of the Healing Effect of Walking Activities According to the Difference in FOREST ENVIRONMENT

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Abstract

The aim of this study is to prevent lifestyle-related diseases, to maintain and improve health in daily life by analyzing the healing effects after walking around residential areas near the residential area within the living zone that urban residents usually used by urbanites as a place for health activities. The results of this study were summarized as follows.

First, the result of analyzing the physiological changes before and after the walk showed meaningful that the stress index and blood pressure were reduced in 42 persons who were walking in the walkway with water and forest, the pulse diversity, RMSSD and LF were increased.

Second, according to an analysis of psychological changes after the walking activities, 42 persons(who were walking in the walkway with water and forest) and 44 persons(who were walking in the forest trail) were showed that the negative emotions such as tension, depression, anger, fatigue, and confusion among the six sub-areas of POMS were reduced and the vigor was increased.

Third, the indices which therapeutic effect between walkway and walkway was significantly indicated by the combination effect between the walkway and a point of view, were the systolic blood pressure, pulse rate, and pulse diversity.

Fourth, healing effect of the physiological reaction by promenade and gender was appeared that, for walkway with water and forest, men was effective in blood pressure and women was effective LF and RMSSD, for forest trail, men was effective in blood pressure and women was effective blood pressure and stress.

Fifth, as a result of POMS, the men walking in walkway with water and forest showed healing effects in all areas except fatigue and confusion, and women in all areas. In the forest trail, men were effective in areas except confusion and vigor, while women were effective in areas except depression and vigor.

Sixth, the correlation between age and physiological response was appeared to have low positive in stress index and systolic blood pressure, while SDNN, LF and HF were showed to have a low negative correlation.

Based on this, if we make a walk a life in environment where water and forest coexist, or in environment where forests are located, it will help prevent lifestyle-related diseases, maintain and improve health, and reduce medical expenses. In addition, it is expected to help in the green space of urban and creation of promenade, and it is considered that will be significance as a practical study that links forest healing with real life.

[Keywords] Healing, Living Zone, Lifestyle-Related Diseases, Medical Expenses, Environment

1. Introduction

Humankind has been evolving for 5 million years and has lived in a natural environment, not a city, more than 99.99% of its existence[1]. The global urbanization rate was only 15% 100 years ago, 30% in 1950, and now 54%. Although 64% of the country's land is made up of forests,

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urban areas account for about 16.7% of the total area as of 2018, with 47.59 million of the total population of 51.82 million living in urban areas(91.8%)[2]. High urbanization leads to reduced contact with the natural environment, and city dwellers are exposed to the possibility of developing diseases due to various stress including the constant noise, excessive lighting, and large amount of fine dust[3]. In order to solve social problems related to urbanization and the stress of urban residents, the concept of forest recreation has been disseminated since 1990 and forest lodges have been created as a recreation area or a place for urban dwellers to meet with nature without destroying the natural environment. This forest lodge policy has won high public support among the various policies of the Korea Forest Service[4]. As the public demand for forest healing expanded due to increased demand for healing, increased role of forest healing due to low birth rate and aging population, and the public demand for forest healing expanded due to proven health improvement and high satisfaction, the government expanded the creation of healing forests for the establishment of a forest healing service provision network along with forest healing promotion policies. However, since most of the healing forests are located in the suburbs, which take an average of 90 minutes to travel from downtown areas, it is difficult to use in daily life for those with no mobility and programs requiring repeated participation, such as for forest prenatal education for pregnant women and dementia prevention for elderly people. The Korea Forest Service defines 'urban forests' as parks, school forests, forest parks, and street trees(forests) that are created and managed for the public's health, recreation, emotional cultivation, and handson activities[6]. Kim Gyeong-mok(2012)[7] talks about forest environment including healing forests, natural recreational forests, urban forests, and forest environment(school, village, and landscape forests), and places that utilize forest environmental factors in everyday life. In a study on the effects of environmental differences, Lee Jeong-hee(2009)[3] said that the water-and-forest environment showed the most positive changes after exposing three types of images for a few minutes - forest-only environment, water-and-forest environment, and urban environment. In addition, a number of studies on environmental differences were reported, such as comparison of the scenery appreciation and the effects of walking in urban and forest environments[8][9], valley and forest trail[10], and urban landscape appreciation[11]. In Japan, it is also stated that different effects are expected depending on the diversity of the forest bathing course - e.g. increased vitality in bright and refreshing space, reduced tension and feeling of comfort in sacred and natural space[12]. Although their research suggests that there are differences in healing effects depending on the environmental differences, practical research that has been linked to real life is lacking, with urban trails, the site of health activities around the residential area that urban dwellers commonly use. In response, this study divided the popular trails around urban dwellings into suburbs and cities depending on the environment. Suburban areas were divided into forest trails and waterforest trails and urban areas were divided into urban riverside trails to discover the effects of walking activities by differences in the environment on human physiology and psychology.

2. Methods

2.1. Study subject

This study was conducted on adults in their 40s to 60s who had no restrictions on their mobility. Of the 128 people who agreed to the experiment after sufficient explanation in advance, data of the final 122 people were used for analysis, with the exception of six who had errors in measurement or who did not respond to the questionnaire. The distribution of the number of subjects by trail type was 42 people on the water-forest trail, 44 on the forest trail, and 36 on the urban riverside trail, with the proportion of women slightly higher at 46.7% for men and 53.3% for women. The average age of the subjects was 53.

Table 1. Study subject.

Description		Men	Women	Total	Average age
Culture	Water-forest	19	23	42(34.4)	53.4
Suburb	Forest	22	22	44(36.1)	52.5
Urban	Urban riverside	16	20	36(29.5)	53.6
Total		57(46.7)	65(53.3)	122(100)	53.1

2.2. Research tools

2.2.1. Physiological response measurement

Blood pressure, pulse, pulse diversity, SDNN(Pulse standard deviation), LF(power in Low Frequency range), HF(power in High Frequency range), LF/HF and RMSSD(Average deviation), and stress index measured by uBiomacpa were used as the physiological response metrics before and after the walk.

2.2.2. Psychological response measurement

Profile of Mood States(POMS) was used as the psychological response measurement. In this study, the measurement used by Jeong Na-ra(2012)[13] as the Korean-style measurement of mood states that Yeun and Shin-Pa demonstrated(2006)[14] with Profile of Mood States-B(POMS-B) developed by McNair et al.(1992)[15].

2.3. Research procedure

Physiological and psychological response measurements were made on 122 people who agreed to the experiment after fully explaining the purpose and method of the study in advance. After taking a 20-minute break before taking a walk on the trail, the mood states test(psychological response test) was conducted first, and then the physiological test was conducted using a blood pressure gauge and a uBioemacpa. After the tests, the subjects took a walk at the selected trails for 60 minutes, during which food other than water was restricted. After a 20-minute break after returning from the walk, psychological and physiological response tests were conducted in the same way as those before the walk. The research procedure is shown in <Figure 1>.

Figure 1. Research procedure.



2.4. Data analysis

The extracted data were analyzed using SPSS Statistics 21.0. The pre-equivalence check of physiological and psychological response indicators was conducted with One-way ANOVA. Differences in healing effects between trails and changes in physiological and psychological by trails were analyzed using Two-way repeated measured ANOVA. Wilcoxon Signed Ranked Test for the purpose of identifying gender comparison by trails, and Paired Samples t-test for all the subjects by gender were used for the analysis.

3. Results & Discussion

3.1. Analysis of the physiological effects

The results of the analysis of the physiological aspects of the healing effects of walking activities according to the differences in environment are shown in <Table 2>.

Table 2. The results of the analysis of the physiological aspects of the healing effects of walking activities according to the differences in environment.

		- 1	Before	After				_	
Index		Trail	M(SE)	M(SE)	ma	р	Source	F	р
	Sub-	Water-forest	47.62 (1.819)	42.50 (1.838)	-5.12	.003	Trail	.963	.385
Stress	urb	Forest	43.61 (1.777)	40.23 (1.795)	-3.39	.044	Time	6.757	.011
	Ur- ban	Urban riverside	43.08 (1.964)	43.78 (1.985)	.69	.706	Trail*time	2.801	.065
	Т	otal (n=122)	44.84	42.06	-2.78				
Svs-	Sub-	Water-forest	132.40 (2.979)	123.59 (2.655)	-8.81	.000	Trail	3.209	.044
tolic blood	urb	Forest	125.27 (2.911)	112.34 (2.594)	-12.93	.000	Time	74.774	.000
pres- sure	Ur- ban	Urban riverside	127.75 (3.218)	123.44 (2.868)	-3.97	.021	Trail*time	6.040	.003
	Т	otal (n=122)	128.45	119.49	-8.96				
Diac-	Sub-	Water-forest	86.67 (1.810)	81.00 (1.632)	-5.67	.000	Trail	2.491	.087
tolic	urb	Forest	81.75 (1.768)	76.068 (1.594)	-5.68	.000	Time	38.561	.000
pres- sure	Ur- ban	Urban riverside	83.39 (1.955)	80.86 (1.763)	-2.53	.067	Trail*time	1.870	.159
	Т	otal (n=122)	83.42	78.69	-4.73				
		Water-forest	70.50 (1.524)	71.52 (1.804)	1.02	.398			
Pulse	urb	Forest	71.73 (1.489)	75.34 (1.763)	3.61	.003	Trail Time	1.049 3.178	.353 .077
	Ur- ban	Urban riverside	74.06 (1.546)	73.22 (1.811)	83	.524		3.273	.041
	Т	otal (n=122)	71.99	73.40	1.41				
	Sub-	Water-forest	42.38 (2.335)	47.48 (2.402)	5.06	.021	Trail	.630	.534
Pulse diver-	urb	Forest	46.68 (2.281)	48.59 (2.347)	1.91	.373	Time	.903	.344
sity	Ur- ban	Urban riverside	46.25 (2.522)	42.92 (2.594)	-3.33	.161	Trail*time	3.463	.035
	Т	otal (n=122)	46.57	48.12	1.55				
SD	Sub-	Water-forest	38.36 (2.217)	38.85 (2.186)	.49	.811	Trail Time	.028 .018	.973 .895
NN	urb	Forest	39.61 (2.166)	36.95 (2.136)	-2.66	.187	Trail*time	1.168	.315

	Ur- ban	Urban riverside	38.10 (2.394)	39.79 (2.361)	1.69	.448			
	Т	otal (n=122)	38.73	38.44	29				
	Sub-	Water-forest	6.21 (.141)	6.51 (.126)	.30	.013	Trail	1.189	.308
LF	urb	Forest	6.49 (.137)	6.74 (.123)	.24	.033	Time	8.323	.005
	Ur- ban	Urban riverside	6.52 (.152)	6.58 (.136)	.06	.662	Trail*time	1.059	.350
	Т	otal (n=122)	6.40	6.61	.21				
	Sub-	Water-forest	5.87 (.100)	6.00 (.109)	.13	.191	Trail	.538	.585
HF	urb	Forest	6.00 (.098)	6.08 (.107)	.09	.368	Time	.061	.805
	Ur- ban	Urban riverside	6.00 (.108)	5.83 (.118)	17	.106	Trail*time	2.512	.005
	T	otal (n=122)	5.95	5.98	.03				
	Sub-	Water-forest	1.06 (.020)	1.08 (.017)	.02	.312	Trail	1.417	.247
LF/HF	urb	Forest	1.08 (.020)	1.10 (.017)	.03	.155	Time	5.804	.018
	Ur- ban	Urban riverside	1.09 (.022)	1.13 (.019)	.04	.091	Trail*time	.158	.854
	Т	otal (n=122)	1.08	1.10	.02				
	Sub-	Water-forest	36.74 (2.327)	41.55 (2.318)	4.80	.018	Trail	.564	.570
RMSSD	urb	Forest	38.52 (2.273)	38.51 (2.265)	016	.994	Time	1.604	.208
	Ur- ban	Urban riverside	36.17 (2.513)	35.86 (2.504)	306	.888	Trail*time	2.007	.139
	T	otal (n=122)	37.91	38.67	0.76				

3.1.1. Changes in the stress index before and after a walk by trails

The stress index measured by the uBiomacpa indicates a physiologically relaxed state due to the stability of the autonomic nerve, since it is expressed in numerical values of pulse diversity, heart rate distribution, autonomic nervous balance, sympathetic activation, parasympathetic activation, pulse standard deviation, etc. Analysis of the results indicated that there was no significant interaction between the trail and the time, so there was no difference in the healing effect between the trails(F=2.801, p=.065). A comparison of responses with the interaction between the trails and the time showed that the stress after walk on a water-forest trail and forest trail decreased by 10.8% and 7.8% respectively. However, the stress index increased slightly, albeit not significantly, after a walk on the urban riverside trail. The stress index before and after a walk for the entire subjects showed a significant difference(F=6.757, p=.011) of a 6.2% decrease. The pre- and post-effects of each trail showed that the suburban trails were effective in reducing stress and making it more physiologically relaxed. This was consistent with the results of Park Beom-jin[8] and Choi Gwang-min[16] of the preceding studies comparing stress level after a walk in urban and forest environments and was similar to the findings of Park Hyeon-soo(2014) [17] that showed a significantly reduced stress after forest-healing and mountain climbing in the comparative study of forest-healing, mountain climbing, and aerobic activities. The case of the water-forest trail, which showed the greatest stress reduction effect, can be seen as the effect that the unconscious comfort and stability of humans who have affection

for the grasslands and forests of the anion and savanna and the habitats of the forests around rivers and lakes have affected the reduction of stress.

3.1.2. Changes in systolic blood pressure before and after a walk by trails

There was a significant differences among trails in terms of interactions between trail and time(F=6.040, p=.003). In other words, it was confirmed that there was a difference in the healing effects by trails. Comparisons by responses with interactions between trails and time considered showed that both suburban and urban trails showed a significant difference, and also in the comparison between before and after a walk for the entire subject, systolic blood pressure reduced 7.0%. Forest trail showed the most significant blood pressure drop effect of 10.3%, followed by water-forest trail(6.7%) and urban riverside trail(3.1%). This is seen as a result of many motor effects because of a topographical feature that has uphills and downhills, causing blood vessels to relax and thus reducing blood pressure. It also revealed that a walk along the suburban and urban riverside trails suppressed sympathetic nerve action and activated parasympathetic nerves, so blood pressure was lowered and physiologically relaxed. These results were consistent with the results of other preceding studies(Jeong Na-ra 2013, Shin Ok-soon 2013)[15][18] dealt with forest activities.

3.1.3. Changes in diastolic blood pressure before and after a walk by trails

There was no significant interaction between the trails and the time, so there was no difference in the healing effect among the trails(F=1.870, p=.159). The comparison by response with the interaction between the trails and time showed a decrease in the diastolic blood pressure of the entire subject(F=38.561, p=.000). A walk on suburban water-forest trails(p=.000) lowered 6.9%, and forest trails lowered(p=.000) 6.9%, which indicated a significant effect. A walk on the urban riverside trails lowered diastolic blood pressure, it was not significant. The trail with the greatest effect of reducing diastolic blood pressure was the forest trail, which had the same result in the case of systolic blood pressure. It showed that the environment that affected the reduction of diastolic blood pressure was the water-forest and forest trails.

3.1.4. Changes in pulse before and after a walk by trails

There is a significant interaction between the trails and time, so there were differences in healing effects among the trails(F=3.273, p=.041). With 3.61 seconds average difference before and after a walk on the forest trail, 1.02 second increase for water-forest trail, and 0.83 second decrease for the urban riverside trail, it showed that there were significant differences in healing effects among the trails. Comparison by response with the interaction between the trails and time adjusted, only the forest trail had a significant difference before and after a walk(p=.003). The increase in pulse(5.0%) is thought to be the result of the lack of sufficient rest after a walk due to the effect of the movement up and down along the ridge of the mountain, and it suggests further studies need to take more careful approaches regarding this issue. These results were similar to those of preceding studies on the forest activities done by Shin Bang-shik(2018)[19], Shin Ok-soon(2013)[18], and Song Cho-rong(2015)[20].

3.1.5. Changes in pulse diversity before and after a walk by trails

The higher the pulse diversity, the healthier the person is. A significant difference in the effect of coupling the trail and time(F=3.463, p=.035), so there is a difference in the healing effect depending on the environmental differences among the trails. The result of comparisons by response with the interaction between the trails and time adjusted showed an increase of 11.9% only with the water-forest trail. This can be seen as a positive effect of a walk on water-forest trails, which strengthens the ability to cope with external stress.

3.1.6. Changes in SDNN(Standard Deviation of all N-N Interval) before and after a walk by trails

SDNN indicates the body's adaptability to the external environment, and the higher the standard range by age, the better. After the experiment, the difference was determined that there was no significant interaction between the trail and time(F=1.168; p=.315), so the difference in healing effect among the trails did not appear. Comparisons by responses with the interaction between the trails and time adjusted showed an increase in the water-forest and urban riverside trails and a decrease in the forest trails. However, it is deemed that there is no significant differences and therefore there is no effect of the walk activity. This was a result consistent with the research of Shin Bang-shik(2018)[19].

3.1.7. Changes in LF(power in low frequency range) before and after a walk by trails

LF is a low-frequency component that reflects the activity of the blood pressure control mechanism, which is high in tension or excitation, and when stress builds up, it is below the standard range by age and low in numbers. The most appropriate figure is one third below the standard range by age. After the experiment, the difference was determined that there was no significant interaction between the trails and time(F=1.059, p=.350), so there was no difference in healing effect among the trails. The comparison by responses with the interaction between the trails and time adjusted showed an increase of 3.3% for the entire subject, thus a significant difference(F=8.323, p=.005). Also, an increase of 4.8% and 3.7% for the water-forest and forest trails, respectively, showed a significant difference. The activation of the sympathetic nerve can be seen as an increase in the appropriate value within the standard range for balancing the autonomic nerves by a stimulus by the natural environment in the suburbs.

3.1.8. Changes in HF(power in high frequency range) before and after a walk by trails

HF is an indicator of parasympathetic nerve activity with a standard range of 3.45 to 6.68Ln for by age(50s) and increases in indicators are activated at rest or relaxation. Analysis of the results indicated that there was no significant interaction between the trails and the time, so there was no difference in the healing effect between the trails(F=2.512, p=.085). Comparison by responses with the interactions between trails and time adjusted, although there was no significant difference before and after, an increase after a walk for water-forest and forest trails and a decrease for the urban riverside trail. This can be judged that a walk not have a significant effect on the HF activation.

3.1.9. Changes in LF/HF before and after a walk by trails

The LF/HF, which indicates the autonomic nervous system that shows the ratio of the degree of the sympathetic and parasympathetic activation, indicates the index of immunity, and the standard range for age group(50s) is 0.84 to 2.64Ln. However, 1.0 to 1.2Ln by day, 0.9 to 1.1Ln by night are appropriate values, and because the sympathetic nerves are accelerated by day than by night, they appear higher at day than at night. Analysis of the results showed no significant interaction between the trails and time, so there was no difference in healing effect among the trails(F=.158, p=.854). Comparison by responses with the interaction between the trails and time adjusted showed an increase for all the trails, but there was no significant difference. However, there was a significant change of 1.9% increase for all the 122 people(F=5.804, p=.018). The increase in LF/HF is considered as a rise to the appropriate level within the standard range. It was different from the preceding study by Park Beom-jin(2010)[8] and was consistent with the findings of Shin Bang-shik (2018)[19].

3.1.10. Changes in RMSSD(Root Means Square of Standard Deviation) before and after a walk by trails

RMSSD is another method of determining the degree of parasympathetic nerve activation, which appears high during sufficient rest or relaxation and is also called "heart stability." The standard range for the age(50s) is between 13 and 57bpm, and over 40bpm is considered healthy, 20 to 40bpm is normal, 10 to 20bpm is management needed, and under 10bpm is medical attention required. There was no significant interaction between the trails and time, so there was no difference in healing effect among the trails(F=2.007, p=.139). The result of comparison by responses with interactions between trails and time adjusted showed a signifiant changes in RMSSD for water-forest trails with 13% increase. This can be said to have caused the environment where water and forests coexist to activate the parasympathetic nerve, causing the heart to stabilize.

3.2. Analysis of effects on psychological aspects

The results of an analysis of psychological aspects of the healing effect of walking activities according to the differences in environment are shown in <Table 3>.

Indox		Trail	Before	After	md	n	Sourco	E	n
muex			M(SE)	M(SE)	mu	μ	Jource	I	μ
	Sub-	Water-forest	1.48 (.093)	1.15 (.073)	33	.000	Trail	.038	.963
Ten-	urb	Forest	1.47 (.091)	1.17 (.071)	30	.000	Time	53.575	.000
sion	Ur- ban	Urban riverside	1.46 (.100)	1.22 (.078)	24	.001	*time	.425	.650
	Т	otal (n=122)	1.47	1.18	-0.29				
	Sub-	Water-forest	1.42 (.093)	1.12 (.065)	30	.000	Trail	.149	.862
De- pres-	urb	Forest	1.32 (.091)	1.11 (.065)	21	.003	Time	32.427	.000
sion	Ur- ban	Urban riverside	1.33 (.100)	1.12 (.071)	21	.006	*time	.574	.565
	Total (n=122)		1.36	1.12	-0.24				
	Sub-	Water-forest	1.54 (.089)	1.13 (.070)	41	.000	Trail	.313	.732
Anger	urb	Forest	1.40 (.087)	1.13 (.068)	27	.001	Time	55.800	.000
-	Ur- ban	Urban riverside	1.38 (.096)	1.14 (.076)	24	.002	*time	1.583	.210
	Т	otal (n=122)	1.44	1.14	-0.30				
	Sub-	Water-forest	1.54 (.089)	1.23 (.077)	31	.000	Trail	.114	.893
Fa-	urb	Forest	1.50 (.087)	1.24 (.075)	26	.000	Time	47.291	.000
tigue	Ur- ban	Urban riverside	1.57 (.096)	1.28 (.083)	29	.000	*time	.132	.876
Т		otal (n=122)	1.53	1.25	-0.28				
Con-	Sub-	Water-forest	1.83 (.075)	1.54 (.065)	29	.000	Trail Time	.533 17.809	.588 .000
fusion u	urb	Forest	1.78 (.074)	1.60 (.063)	18	.011	Trail	1.835	.164

Table 3. The results of an analysis of the healing effect of walking activities according to the differences in environment.

	Ur- ban	Urban riverside	1.81 (.081)	1.73 (.070)	07	.331	*time		
	Т	otal (n=122)	1.80	1.61	-0.19				
	Sub-	Water-forest	2.85 (.085)	3.45 (.153)	.60	.000	Trail	.023	.977
Vigor	urb	Forest	2.96 (.083)	3.32 (.149)	.37	.003	Trail	35.159	.000
-	Ur- ban	Urban riverside	2.95 (.092)	3.28 (.165)	.33	.015	*time	1.360	.261
	Т	otal (n=122)	2.92	3.36	.44				
Total	Sub-	Water-forest	1.83 (.067)	1.45 (.062)	37	.000	Trail	.070	.932
mood dis-	urb	Forest	1.75 (.066)	1.49 (.061)	26	.000	Trail	74.960	.000
turb- ance	Ur- ban	Urban riverside	1.77 (.072)	1.54 (.067)	23	.000	*time	1.610	.204
	Т	otal (n=122)	1.78	1.49	29				

3.2.1. Analysis of changes in tension(T: tension) before and after a walk by trails

Analysis of tension(a subarea of POMS) before and after a walk showed that there was no significant interaction between the trails and time, so there were no significant differences in healing effect among the trails(F=.425, p=.650). Comparison by responses with the interaction between the trails and time adjusted showed significant differences before and after a walk for the entire research subject and by trails. Tension decreased 22% for water-forest trail, 20% for forest trail, and 16.4% for urban riverside trail. These results showed that walk activities were effective in reducing tension by providing psychological rest. This result was consistent with that of a study on decreased tension after a walk in a forest environment done by Yim Hyo-jin et al.(2012)[11] and Park Beom-jin(2010)[8].

3.2.2. Analysis of changes in depression(D: depression) before and after a walk by trails

Analysis of depression(a subarea of POMS) before and after a walk showed that there was no significant interaction between the trails and time, so there were no significant differences in healing effect among the trails(F=.574, p=.565). Comparison by responses with the interaction between the trails and time adjusted showed significant differences before and after a walk for the entire research subject(F=32.427, p=.000) and by trails. Depression decreased 21% for water-forest trail, 15.9% for forest trail, and 15.7% for urban riverside trail. The decrease in depression on the three trails can be seen as a reduction in depression due to daytime walk activities that have activated the secretion of serotonin with adequate amount of sunlight. This was similar to the results of preceding studies, such as that of Ji Gyeong-bae(2012)[21] that showed reduced depression after a walk in a forest. The highest effect of walk on water-forest trails can be attributed to the harmonious healing factors of landscape, anion, and indirect sunlight.

3.2.3. Analysis of changes in anger(A-H: anger and hostility) before and after a walk by trails

Analysis of anger(a subarea of POMS) before and after a walk showed that there was no significant interaction between the trails and time, so there were no significant differences in healing effect among the trails(F=1.583, p=.210). Comparison by responses with the interaction between the trails and time adjusted showed significant differences before and after a walk for the entire research subject(F=55.800, p=.000) and by trails. Anger decreased 26.6% for waterforest trail, 19.3% for forest trail, and 17.4% for urban riverside trail. This was consistent with the results of preceding studies, such as that of Yim Hyo-jin(2012)[11], Ji Gyeong-bae(2012)[21], Park Beom-jin(2010)[8] that showed reduced anger after a walk in a forest. It is considered a result of psychological relaxation by healing factors of the walking environment working as inhibitors to the sympathetic nerves and that the greatest effect was seen on the water-forest trail. It is believed that rich anion, phytoncide, natural sound, indirect sunlight, and peacefulness of the landscape worked as positive factors.

3.2.4. Analysis of changes in fatigue(F: fatigue) before and after a walk by trails

Analysis of fatigue(a subarea of POMS) before and after a walk showed that there was no significant interaction between the trails and time, so there were no significant differences in healing effect among the trails(F=.132, p=.876). Comparison by responses with the interaction between the trails and time adjusted showed significant differences before and after a walk for the entire research subject(F=47.291, p=.000) and by trails. Fatigue decreased 20.1% for water-forest trail, 17.3% for forest trail, and 18.5% for urban riverside trail. These results showed that walking activities have the effect of reducing fatigue due to psychological relaxation caused by natural stimuli. This was consistent with the results of Yim Hyo-jin et al (2012)[11], Ji Gyeong-bae(2012)[21], and Park Beom-jin(2010)[8] who showed reduced fatigue after a walk in forest.

3.2.5. Analysis of changes in confusion(C: confusion) before and after a walk by trails

Analysis of confusion(a subarea of POMS) before and after a walk showed that there was no significant interaction between the trails and time, so there were no significant differences in healing effect among the trails(F=1.835 p=.164). Comparison by responses with the interaction between the trails and time adjusted showed significant differences before and after a walk for the entire research subject(F=17.809, p=.000) with 10.6% decrease. Confusion decreased 15.8% for water-forest trail and 10.1% for forest trail. This is believed to be effects of phytoncide, anion, green, and white noise that are healing factors suburban trails, inducing alpha brain waves. The result was similar to studies by Ji Gyeong-bae(2012)[21] and Park Beom-jin(2010)[8] that showed less confusion after walking in a forest.

3.2.6. Analysis of changes in vigor(V: vigor) before and after a walk by trails

Analysis of vigor(a subarea of POMS) before and after a walk showed that there was no significant interaction between the trails and time, so there were no significant differences in healing effect among the trails(F=1.360 p=.261). There were significant differences before and after a walk for the entire research subject(F=35.159, p=.000) and by trails. Vigor increased 21% for water-forest trail, 12.5% for forest trail, and 11.1% for urban riverside trail. This was similar to the results of the preceding studies of Yim Hyo-jin(2012)[11], Park Beom-jin[8], and Song Cho-rong(2015)[20]. It is believed to be the result of increased vigor by outside environmental stimuli during walking activities.

3.2.7. Analysis of changes in total mood disturbance(TMD: total mood disturbance) before and after a walk by trails

The total mood disturbance is an average of all six sub-areas(tension, depression, anger, fatigue, confusion, and vigor) after reverse scoring vigor, and the higher the number, the worse the mood is. Analyzing the comparative results of TMD before and after a walk showed that there was no interaction effect between the trails and time, so there was no significant differences in the healing effect among trails(F=1.610 p=.204). With the interaction between the trails and time adjusted, the comparison by responses showed that a walk activity is effective in improving the mood, with a TMD decrease of 20.2% in a water-forest trail, 14.9% in a forest trail, and 13.0% in an urban riverside trail. This was similar to the results of preceding studies such as Yim Hyo-jin(2012)[11] and Park Beom-jin(2010)[8]. It is believed that the main reason for the effect was shown in the order of the water-forest, forest, and riverside trail is

that phytoncide, anion, sound, landscape, indirect sunlight, and color in the suburban environment worked as healing factors.

3.3. Gender difference of healing effect of a walk by differences in the forest environment

<Table 4> shows the result of the analysis of gender difference of healing effect of a walk by differences in the forest environment.

Measure-	Index	Gender	Before	After	md	7(+)	n
ment	Index	(n=122)	M(SD)	M(SD)	mu	2(t)	P
		Men(n=57)	45.18 (12.284)	43.89 (12.591)	-1.28	.864	.392
	Stress	Women (n=65)	44.54 (11.571)	40.45 (11.112)	-4.09	2.974	.004
	Systolic	Men (n=57)	132.37 (18.455)	122.46 (16.946)	-9.91	5.906	.000
	pressure	Women (n=65)	125.03 (19.675)	116.89 (18.427)	-8.14	6.312	.000
	Diastolic	Men (n=57)	87.70 (12.527)	82.14 (12.029)	-5.56	4.463	.000
	pressure	Women (n=65)	80.62 (10.152)	76.59 (8.782)	-4.03	4.582	.000
		Men (n=57)	72.49 (9.474)	74.21 (12.139)	1.71	-1.506	.138
	Pulse	Women (n=65)	71.55 (9.215)	72.69 (9.721)	1.14	-1.237	.221
Physiologi-	Pulse diversity	Men (n=57)	44.86 (15.477)	45.77 (16.158)	.91	456	.650
cal aspects		Women (n=65)	45.26 (14.946)	47.20 (15.229)	1.93	-1.118	.268
	CDNN	Men (n=57)	36.69 (12.232)	36.87 (14.892)	.18	110	.913
	SDNN	Women (n=65)	40.52 (17.707)	39.81 (13.328)	71	.401	.690
	15	Men (n=57)	6.44 (1.013)	6.54 (.987)	.10	-1.060	.294
		Women (n=65)	6.38 (.825)	6.68 (.634)	.30	-3.077	.003
		Men (n=57)	5.95 (.604)	5.94 (.782)	01	-038	.970
		Women (n=65)	5.96 (.683)	6.00 (.642)	.05	678	.500
		Men (n=57)	1.08 (.142)	1.10 (.120)	.02	-1.205	.233
	LF/HF	Women (n=65)	1.07 (.120)	1.11 (.106)	.04	-2.129	.037

Table 4. The result of the analysis of gender difference of healing effect of a walk by differences in the forest environment.

	RM	Men (n=57)	34.75 (12.094)	35.78 (16.378)	1.03	601	.550
	SSD	Women (n=65)	39.38 (16.930)	42.49 (13.753)	3.11	-1.747	.085
	Tonsion	Men (n=57)	1.49 (.675)	1.29 (.607)	20	3.766	.000
	Tension	Women (n=65)	1.45 (.526)	1.08 (.266)	37	6.736	.000
	Doprossion	Men (n=57)	1.45 (.683)	1.22 (.571)	23	3.791	.000
	Depression	Women (n=65)	1.28 (.503)	1.03 (.201)	25	4.424	.000
	Angor	Men (n=57)	1.47 (.662)	1.21 (.583)	26	4.375	.000
	Anger	Women (n=65)	1.42 (.497)	1.07 (.274)	35	6.208	.000
Psychologi-	Fatigue	Men (n=57)	1.59 (.667)	1.39 (.615)	20	3.295	.002
cal aspects		Women (n=65)	1.49 (.474)	1.13 (.313)	36	6.590	.000
	Confusion	Men (n=57)	1.82 (.556)	1.70 (.463)	12	2.168	.034
	Confusion	Women (n=65)	1.79 (.416)	1.54 (.374)	25	3.806	.000
	Minor	Men (n=57)	3.00 (.533)	3.40 (.930)	.40	-3.761	.000
	Vigor	Women (n=65)	2.84 (.555)	3.32 (1.034)	.48	-4.647	.000
	7145	Men (n=57)	1.80 (.523)	1.57 (.502)	23	4.710	.000
	TMD	Women (n=65)	1.76 (.336)	1.42 (.269)	34	7.558	.000

The healing effect of walking activities due to differences in forest environment was shown to vary depending on gender. Physiological changes according to gender by trails showed that only blood pressure decreased for men(systolic 6.6% and diastolic 6.3%) in a water-forest trail, while for women stress(15.3%) and blood pressure(systolic 6.7% and diastolic 6.7%) decreased and LF(5.9%) and RMSSD(20.1%) increased. On the water-forest trail, blood pressure showed a more positive effect on women than on men. In the forest trail, only blood pressure(systolic 11% and diastolic 8.6%) decreased for men while women showed positive effects at stress(11.1%) and blood pressure(systolic 9.6% and diastolic 5.2%). The positive healing effect of blood pressure on the forest trail better for men, and it is believed that dynamic activities on terrain with slopes are effective for men's blood pressure reduction. On the urban riverside trail, only men experienced a decrease in diastolic blood pressure(3.4%). Comparing the healing effect of the three trails, the forest trail was better than the urban riverside trail, and the water-forest trails was better than the forest trail. The healing effect was better for women than for men. TMD, the result of POMS, a measure of psychological response according to gender before and after a walk, showed that a walk on a water-forest trail decreased it by 12.3% for men and 26.5% for women and a walk on a forest trail decreased it by

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15.1% for men and 14.6% for women. In the case of the urban riverside trail, it decreased 9.8% for men and 15.6% for women. Lower TMD means better mood, and a walk on a water-forest trail and urban riverside trail had better effect on women than on men while the forest trail had better effect on men than on women. This is consistent with the result of lower blood pressure of men after a walk on a forest trail, which is thought be effective in improving men's mood. TMD in the overall comparison among the entire subject showed a decrease of 12.8% for men and 19.3% for women, and it was shown that a walk in suburban and urban areas proved to be more effective in improving women's mood than men's.

4. Conclusion

This study was conducted to analyze the effects of walking activities on the physiological and psychological reactions of the human body due to differences in forest environment. The environment was largely divided into suburban and urban areas. The suburbs were divided into water-forest trails and forest trails and the urban area was divided into riverside trails to discover the healing effect by selecting destinations for easy access and health activities for ordinary people in their daily lives. Based on this, the purpose was to promote the health of urban dwellers and contribute to the prevention of diseases by selecting a healing environment and utilizing it in everyday life. The subjects were targeted at men and women in their 40s to 60s. Among total 122 people with no mobility hindrance, 42 were for water-forest trails, 44 were for forest trails, and 36 were for the urban riverside trails. The analysis data were measured and analyzed before and after a walk, including physiological indexes of blood pressure, pulse, stress, pulse diversity, LF(sympathetic activation), HF(parasympathetic activation), LF/HF(autonomic nerve balance), SDNN(Standard Deviation of all N-N Interval), and RMSSD(Root Means Square of Standard Deviation) and psychological index of POMS. The research results are as follows.

First, changes in physiological indexes after a walk due to environmental differences showed significant differences in stress, blood pressure, pulse, pulse diversity, LF, and RMSSD. A walk on a water-forest decreased stress and blood pressure and increased pulse diversity, LF, and RMSSD. A walk on a forest trail decreased stress and blood pressure and increased pulse and LF. The urban riverside trail had only the effect of reducing systolic blood pressure.

Second, the order of the great physiological healing effect after a walk in terms of stress decrease comes the water-forest trail(10.8%), followed by the forest trail(7.8%). For LF, the waterforest trail(4.8%), then forest trail(3.7%). For systolic blood pressure, forest trail(10.3%), waterforest trail(6.7%), then urban riverside trail(3.1%). For diastolic pressure, forest trail(6.9%), then water-forest trail(6.5%). For Pulse diversity and RMSSD, only water-forest trail had a healing effect with 11.9% and 13%, respectively.

Third, there were differences in the healing effect of walking activities due to differences in forest environment by gender. Physiological changes according to gender by trails showed that only men's blood pressure(systolic 6.6% and diastolic 6.3%) decreased in water-forest trail, while women's stress(15.3%), blood pressure(systolic 6.7% and diastolic 6.7%) decreased, and LF(5.9%) and RMSSD(20.1%) increased. TMD, the result of POMS, a measure of psychological response according to gender before and after a walk, showed that men and women decreased by 12.3% and 26.5%, respectively, after a walk on the water-forest trail, while on the forest trail by 15.1% for men and 14.6% for women. Overall comparison of the subjects showed that TMD decreased 12.8% for men and 19.3% for women, which showed that a walk in suburban and urban areas proved to be more effective in improving women's mood than men's.

Based on the results of this study, a walk in the environment where water and forest coexist around one's living quarters will contribute to preventing lifestyle diseases, improving health care, and reducing medical costs. In addition, this study is meaningful in that it is a practical research that links forest healing with real life and is expected to help create green spaces and walk trails in the city.

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6. Contribution

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	Initial name	Contribution
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Corresponding Author*	LWH	-Corresponding 🗹 -Play a decisive role in modification 🗹
Co-Author	PJS	 Significant contributions to concepts, designs, practices, analysis and interpretation of data Participants in Drafting and Revising Papers Someone who can explain all aspects of the paper

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Developing SPORT LEGACY through Post-Use of Mega-Sport Event Facilities: The Case of Winter Sport

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Abstract

Hosting mega-sport events can benefit various areas, including the economy, society, culture, and environment. In detail, a sport event not only promotes the sale of sporting goods and the operation of sports facilities, but also affects various corporate activities such as promotion, advertisement, and product promotion of sports as an opportunity and means for sports to develop into an industry itself. In addition, the promotion effect of not only the host city, but also the companies and tourism resources that are located there can promote the competitiveness of local industries and vitalize the local economy and exert various influence on the community and residents, including enhancing the image of the host city and raising the brand value.

It is true that mega events such as the Olympics are national events that bring together the capabilities of the host region, drawing attention from the public through direct and indirect positive economic effects such as enhancing the brand image of the hosting countries, creating jobs, and boosting tourism. Unlike the Summer Olympics and the World Cup, however, winter sports events involve huge investments in building infrastructure for stadiums, athletes' villages, and other facilities because the number of participating countries and athletes is small and the games are held in areas away from the city. In addition, the use of facilities is relatively difficult compared to summer sports events as they are often held in sparsely populated mountainous areas. Therefore, due to the failure of post-utilization of one-time installations, in which the competition is held in a flashy manner amid the concentration of global attention, its role and function are extinguished after the event, so the government is facing serious reality such as huge facility maintenance and interest repayment on investment costs.

Therefore, this study considered the post-use of mega-sport event facilities and reviewed the plan for postuse of the winter sports stadium, and based on this, presented strategic measures to maximize the postutilization of sports facilities to increase the legacy of mega-sport events, especially winter sports events. The following conclusions were obtained:

First, it is necessary to maximize variable elements in the stadium construction phase to enable the use of various facilities(multi-purpose complexes, multi-functional facilities, mobile facilities, etc.)

Second, to minimize the construction costs of sports facilities and avoid excess or redundancy, the distribution of sports facilities and the selection of sports hub cities should be made (selection and concentration considering sports events and venues)

Third, a construction plan is needed to cover facilities targets not only for professional athletes and local residents, but also for visitors and travelers(overcoming the limitations of winter sports and demographic limitations of host cities, and reviewing the utilization of tourists).

Fourth, various programs related to winter sports need to be developed (increasing efficiency in the utilization of winter sports facilities, linking the cultural industry such as four-season entertainment and concert halls).

Fifth, they need to be commercialized for tourism(attracting foreign visitors and tourists through the development of various tourist products, such as sports experience and stadium tour).

[Keywords] Sport Legacy, Mega-Sport Event, Post-Use, Sport Facility, Winter Sport

1. Introduction

The 2018 PyeongChang Winter Olympics presented a vision of "New Horizons," opening a new horizon for winter sports in a new stage of Asia with great potential together with the young generation worldwide and successfully hosted it with the goal of "leaving a sustainable legacy to the host city and country"[1]. Under these goals, it stated the term "sustainable legacy" and expressed the willingness to leave the Olympic stadium facilities as a long-term legacy. This not only conformed to the IOC's recommendation of "sustained Olympics" but also became an important issue to determine whether the Olympic Games will be successful or not[2].

Until the final bid for the 2018 PyeongChang Winter Olympics was confirmed, a lot of institutions and organizations had published a number of studies on the economic impact of hosting the Winter Olympics on the local economy and the Olympic legacy, but after the final bid was decided, it became difficult to find such studies[3]. Prospects for the economic ripple effects that will be generated after the Olympic bid were largely positive even during the previous bidding for the Winter Olympics. When new stadiums and facilities were built for the games, there were positive expectations on the economic ripple effects such as improving the brand image of the hosting country and creating jobs. However, the financial burden of local and central governments, which had spent a considerable amount of money on the construction of stadiums, has often hampered the development of local governments for a long time since the Winter Olympics and failed to substantially utilize the facilities, thus failing to produce the expected positive effects. Although the Olympic Games are certainly effective for temporary and shortterm stimulus and infrastructure expansion after the hosting the event is decided, other economic effects are not only very limited or even non-existent, but also result in financial burdens beyond the funding available[3][4]. In fact, it is not difficult to find a case in which a stadium facility invested with a large amount of money has been reduced to a white elephant in the past Winter Olympics. The reality is that the athletes use facilities for the games during the event and then the stadiums after the event are abandoned and financial problems such as huge facility maintenance costs and interest payments on facility investment costs follow.

Successful hosting of the Winter Olympics will involve huge investments to prepare facilities such as the best stadiums and athletes' villages. This is especially because unlike the Summer Olympics and the World Cup, the Winter Olympics are held in an area away from the city center[5].

For this reason, hosting the Winter Olympics is always accompanied by facility investments such as stadiums and athletes' villages, and through such investments, the host country is stirred up by social controversy over the over-investments to make stadium facilities a long-term legacy or a landmark for the region or the country. In other words, there are many cases where negative economic ripple effects in the mid- to long-term occur by making excessive facility investments to host the short-term events[6].

Not only the 2018 PyeongChang Winter Olympics, but also the 1998 Nagano Winter Olympics to the 2014 Sochi Winter Olympics resulted in a significant net loss that went straight to the burden of citizens of the host city[7][8]. As Figure 1 shows, the hosting of the Winter Olympics cost a lot of national and local expenses for stadiums, support facilities, infrastructure, and transportation networks, a lot more than was expected during the actual event[5]. This shows that despite the positive economic ripple effects of the Olympics, the trend of exceeding the budget spent on hosting the Games continues, meaning a more firm and systematic approach to the post-utilization of Winter Olympic facilities is needed, and the importance of sports legacy, including the post-utilization of facilities, is being emphasized to streamline the costs of hosting them.





Note: The Oxford Olympic Study(2016).

Today, hosting international sports events such as the Olympics is perceived as comprehensive international events beyond the mere venue of international competitions among the world's sports people. However, there is no lack of criticism about the recent Olympic events being excessively commercial and large-scale, and some argue that pure amateurism is diluted and the intended effect is minimal considering the sheer volume of investment. Some also point out that excessive facility investment to host the short-term event may have negative impact on the economy in the mid- to long-term[9].

The overall cost of the Winter Olympics facilities is far higher than that of other mega-sport event facilities due to the "needs for highly specialized facilities." Specialized facilities for the winter sports are highly inflexible in post-utilization despite the high construction and operating costs. These facilities were built with a focus on training and hosting competitions for top international-level athletes, so after the competition usability for the general public will inevitably be low. When the Olympic stadiums are preserved as the Olympic legacy, it is only natural that they are used as its original purpose of the facility or as a multi-purpose convention center[10].

However, amid this limiting reality, there are clearly good possibilities for recycling stadium facilities after mega-sport event through diversified approaches. Facilities such as an ice rink can be used for cultural and artistic purposes, recreational purposes, school and club sports programs, events such as concerts and exhibition performances, not just for training of athletes or just as a sport stadium. In particular, more rigorous follow-up planning is required in the event of hosting a mega-sport event related to winter sports, which is accompanied by huge financial burden[11].

Therefore, this study aims to present policy suggestions that will be useful for planning the post-use of the facilities for winter sports related mega-sport events and to present strategic measures to maximize the promotion of sports legacy by surveying and analyzing the utilization status of facilities in the past Winter Olympic venues.

2. Methodology

The purpose of this study is to present strategic measures to maximize the increase of sports legacy through the search for post-use measures of the stadiums after mega-sport events. First, the concept of mega-sport event legacy will be newly established through literature research and the components of mega-sport event legacy will be established. In particular, the three areas of sports legacy, that is, physical, economic, and social legacy, presented by Gratton, Dobson, & Shibli(2012), Gratton, Shibli, & Coleman(2009), and Kim(2013) will be used to systematize

the components and theoretical structure and work as a framework for deriving the study results[12][13][14].

Second, the use of each component of mega-sport event legacy will be analyzed through the case study method for stadiums that have been well used and under-utilized after the events. Based on the use of stadiums for past mega-sport events centered on the Olympics, the importance and strategy of the post-use measures of the stadiums will be analyzed.

Third, based on the theoretical system of mega-sport event legacy, the economic value and significance and influence of mega-sport event legacy and the relation between mega-sport event legacy and the regional development will be analyzed.

Finally, based on the results of the literature research and case analysis, ways to use the stadiums after mega-sport events will be sought. Through this, strategic measures to maximize the growth of sports legacy will be presented. Through active application of sports legacy from the stage of bidding for hosting future events, it will attract successful mega-sport events and further provide a framework for the tangible legacy left after the event to have a positive long-term and short-term impact on the regional development.

3. Sport Legacy

The literature states that sports legacy has many meanings, which are difficult to define in a universal manner, but can be described as tangible and intangible values that occur in a host country or host city in general through sports events[11]. Yeom(2012) said that the concept of legacy generally means the positive effects that will emerge after the mega-sport events[15], while Roche(2000) and Mangan(2008) argued that they are all tangible and intangible things that would remain in the long run[16][17]. Through the hosting of mega-sport events, such legacy have had a wide impact on the economy, society, culture, and environment[18][19] and tourism[4]. Yoo(2011) divided the concept of legacy into mental(intangible) and physical(tangible) legacy. Mental legacy refers to the spread of sports spirit and ideology and physical legacy refers to new sports facilities and social overhead capital(SOC) facilities to host sports events[20]. Sports legacy can be used in different languages and cultures in different forms. They have planned-non-planned, positive-negative, tangible-intangible structure[11] and their impacts continue to be applied throughout society, including politics, economy, society, culture, environment, and sports in the host city and country[21].

Recently, as competition among countries to host mega-sport events heat up, the International Olympic Committee(IOC) has set the host city's plan for the Olympic legacy as an important evaluation standard. The change which came after a symposium on the legacy of the Olympic Games held by IOC suggested that more studies should be conducted on the planning and program management of the Olympic legacy. After the symposium, IOC included the need for positive heritage to contribute to the quality of life of the host city and country in the IOC Charter[22].

Types of legacies	Examples	
Sporting	- Continuous use of sporting venues	
Sporting	- Increasing the participation in sports	
	 Promoting image and awareness of the host country 	
Social	- Education of the olympic spirit and values	
	- Enhancing social integration	
Environment	- Revitalization of the cities	
Environment	- Use of environment-friendly energy	

Table 1. Olympic legacies defined by international olympic committee.

Urban	 Renewal and beautification of urban area Improving transportation infrastructure
Economic	- Expanding business opportunities - Creating jobs - Boosting tourism industry

Note: International Olympic Committee (2012). Olympic Legacy.

3.1. Physical legacy

A typical physical legacy is infrastructure. Infrastructure obviously means the sport facilities for the training and competition, but also the general infrastructure of a city such as hotels, airports, roads, telecommunication, housing for athletes, media, and officials, parks, etc.[14][23]. All infrastructure left after an event should be suitable for the development plan of the city, but it has almost always been a big problem called the white elephant[13]. The city of Athens spent \$15 billion on permanent stadiums for the 2004 Olympic Games and now many are abandoned and in various states of disrepair. The stadiums for the 2008 Beijing Olympics are not as rotten as the ones in Athens, but they are losing money because of their inability to secure long-term tenants[24].

Temporary or flexible constructions can avoid negative legacies such as oversized and extraneous facilities[19]. The 80,000-seat main stadium for the London Olympics has been reduced to 25,000 after the Olympics and is being used as a home stadium for one of the Premier League football team, West Ham United[24].

3.2. Economic legacy

The economic legacy from hosting mega-sport events can arise not only from direct legacy but also from indirect aspects, such as increased economic activity, increased production and consumption, job creation, and the rise of GDP through it. Not only will the host cities with a low profile outside and in the country have a large demand for tourism since the sports event, but they will also greatly enhance the awareness of regional and national brands, which will be accompanied by enhanced image and higher prices of export goods. This huge economic ripple effect is the reason why not only local governments but also the national level are competing fiercely to host mega-sport events[4][15].

Each item that constitutes the legacy from a mega-sport event is correlated with each other, not independently influenced by a specific sports event(Kang, 2006; Preuss, 2006). In particular, physical legacies such as sports facilities for training and competition, transportation facilities such as roads, railways, aviation and transport, and tourism facilities such as hotels and restaurants produce continuous economic ripple effects in the various industrial sectors for the local and national economy. From a sport perspective, this physical legacy can maximize the economic value as a new and potential industry by having a profound impact on the development of the sport industry[23].

3.3. Social legacy

The social legacy benefits after hosting the mega-sports event include the pride and spirit of hosting the mega-sport event, the benefits of participating in world culture and events, and social integration. It can also benefit the community and the public through environmental improvement, conservation of natural space, environment-friendly facilities, and the use of renewable energy sources[26][27].

Some of the most important social legacies generated from hosting mega-sport events are the regenerated and enhanced emotions for the public[11]. The mega- sport event gives the nation's leaders a common vision for gaining international prestige, and citizens may be emotionally involved. The pride of hosting such an event also creates confidence that is "I-can-doit', as well as local awareness, image, vision and motivation[11][26][27]. One example is the 1988 Seoul Olympics' creation of a national perspective that includes feelings of vitality, participation and recognition as well as international perception that it is modern and technically upto-date[28]. The Chinese were keen to demonstrate their increasing economic importance through the Olympics in 2008[29].

4. Winter Mega-Sport Events over Time

The 17th Lillehammer Winter Olympic Games has attracted many tourists as a world-class winter sports resort since its preparation stage[30] by planning various events to build stadiums and enhance post-use by minimizing artificial decorations on the site with the plan of constructing the Olympic legacy and sustainable green facilities. The Lillehammer Olympic Bobsleigh & Luge Track, which is used as a national facility for Scandinavian Park, is used as a bobsleigh, luge stadium, a venue for domestic and foreign sports events, a training camp for international competition and for the military, and a bobsleigh experience center for the general public. Especially in the summer of 1993, it became widely popular among tourists by being designed as "Wheel Bob(the summer's equivalent of Bobsledding)"[31].

The Gjøvik Olympic Cavern Hall, where the ice hockey games took place, is the largest artificial cave stadium in the world and is visited by many tourists and is used as a shelter against nuclear, biological, or chemical attacks in case of emergency. In addition, meticulous efforts to protect the environment were added. The organizing committee used potato starch to make the plates to be used during the event and used them as pig feed when the event was over. They had a thorough plan to protect the environment, including the recovery of all the bullets used in biathlon, and received the rave reviews of "White-Green Games" from the IOC president at that time[32].

What's most noteworthy about the Lillehammer Winter Games in particular is that the central and local governments and the Olympic Committee established cooperative governance relationships to maximize the Olympic legacy. The central government and parliament took the lead in successfully inducing local governments, and the municipal authorities and citizens of the cities involving the Olympics, including Lillehammer, actively cooperated. In response to the Norwegian parliament's decision, there was a clear allocation of roles among the central and local governments and the organizing committee before the Lillehammer Olympic Games were promoted in earnest, and such granular organizational power among each of the propellant groups created greater synergy[33].

On the other hand, the 1998 Nagano Winter Olympics and the 2014 Sochi Winter Olympics have become representative venue suffering from the "Curse of the Olympics" due to astronomical facility investments and the lack of a post-use program for those facilities. In the Nagano Olympics, too much money was spent on the construction of stadiums by insisting on state-of-the-art facilities, over-investing in social overhead infrastructure such as roads and airports, and lack of a post-use plan[32]. The Sochi Olympics, in particular, has been a headache for the Russian government due to the government spending of more than \$50 billion, the highest amount ever. Sochi has created 14 new facilities that are underused after the event, and without proper post-use plans, it is costing the Russian government a huge financial loss[34].

The 22nd Vancouver Winter Olympics is Canada's third Olympic Games, along with Montreal Summer Olympics in 1976 and Calgary Winter Olympics in 1988. The Vancouver Olympics were held in distributed areas with not only Vancouver, but also nearby Richmond, Whistler, and donated land in University of British Columbia(UBC).

The Vancouver Olympic Committee(VANOC) has established and implemented construction plans for stadiums and related facilities, with a focus on maximizing their potential and sustainability in the post-use of stadiums and related facilities. In close cooperation with the Olympic partners such as local governments of Whistler and Richmond and UBC, the venues used in the Olympics were divided into recreational, elite sports, and community center purposes. To enhance the sustainability of the stadiums and related facilities, the 'Green-Building Concept' was adopted, being designed, constructed, maintained, and managed in a natural way(including the use of environmentally friendly construction materials, energy, and water resources). Extra efforts were put in the design of the facilities including using rain and heavy water and recycling hot air in buildings, etc. to lower the operating costs of post-management institutions. In addition, from the design phase through public hearings with post-management agencies and local residents, they made efforts to reflect the opinions of post-users as much as possible[35].

"The Hillcrest Curling & Nat Bailey Stadium Park," where curling events were held during the Olympics, has been renamed "the Hillcrest Vancouver Olympic Center" and is operating as a multi-purpose local recreation center. It consists of an ice hockey rink, a gym, a library, and six curling fields and is operating an additional aquatic sports facility, including two additional swimming pools. \$14 million were injected to convert to post-multipurpose facilities and \$34 million more were spent to add an aquatic center. Vancouver Board of Parks & Recreation is the operating body of the Olympic Center[36].

The University of British Columbia(UBC) winter sports center, where ice hockey games were held, is now being actively used as a multi-purpose recreational and sports facility for popular sports revitalization, renamed as the "Doug Mitchell Thunderbird Sports Centre." With UBC as its operating body, the center is used as a 5,000-seat event hall that can host various winter sports programs, such as ice hockey and skating, and a variety of other events, such as concerts and musicals, mainly for youth and young adults[37].

The Richmond Olympic Oval, where the speed skating event took place, was removed after the Olympics, renovated as a mixed sports facility, and is now recognized as the world's best public recreation center[33]. It was constructed from the design phase considering a change from a stadium to a post-Olympic multi-purpose sports center. It serves as the center of the newly constructed waterfront development area. It includes a fitness center, two international standard ice links, 18 badminton courts, 13 volleyball courts, 10 basketball courts, three FIFA standard indoor football fields, a 200-meter track, a 100-meter track with five lanes, and an indoor boat race training course and offers a variety of recreational programs for individuals and organizations. The operator is Richmond Olympic Oval Cooperation under the city of Richmond and has signed a \$1 for 21 years lease contract with Richmond City. After the Winter Olympics, it hosted various domestic sports events for about nine months and also operates training programs to foster promising athletes in various sports. The total number of visitors was tallied at about 400,000 in 2010, with an average of 15,000 members per month using the facilities and operating three adult sports leagues to attract 96,000 visitors. 82 percent of the members currently registered as regular members are citizens of Richmond, and 18 percent are residents of nearby cities[38].

The city of Whistler has established 'Whistler Sports Legacy' as the operator for the post-Olympic stadium and is in charge of managing Whistler Olympic Park, Sliding Centre and Athletes' Center. The purpose of 'Whistler Sports Legacy' is to attract international competitions and provide a variety of winter sports opportunities for visitors[39].

5. Post-use of Sport Facility Strategies

5.1. Reuse of sport facility

The reuse of sport facilities can be much more difficult for the winter sports events than the summers. More facilities can be built with temporary structures(e.g., main stadium reduction, demolitionable temporary stadium, beach volleyball courts in London Olympics) that can be demolished or reduced after the event for the summers, therefore eliminating the need for reuse. However, many of the sports facilities needed for the winter sport events are not so flexible. For example, ski jumps made according to Olympic standards can only be used by some elite athletes. Similarly, possible post-event use for sliding tracks is limited. Winter sports such as luge and bobsleigh generally do not have many fans [40][41]. As a result, the reuse of winter sports facilities often focuses on the training of elite athletes and the hosting of international competitions, so it is not beneficial to the general public [10].

Therefore, it is imperative to establish sufficient post-use strategies through conferences or public hearings involving the national and local governments, private companies, and residents when considering to build sport facilities, especially winter sport facilities. It should be accompanied by efforts to identify the demand for various winter sports that can be held in the future and develop new sports related to winter sports so existing facilities can be continuously recycled at various sport events in the future.

5.2. Winter sports hub city

The number of sites where winter sports can be held is much less than those where summer sports can be held[40]. This is because a high mountain environment is required for skiing competitions and must have reliable snow[42]. In addition, only rich countries can afford to host winter sport events because of the high cost of installing infrastructure[40]. This restriction has so far allowed most of the Winter Olympic Games to be held in the European Alps(e.g., Grenoble, Albertville, Torino), North America(e.g., Calgary, Salt Lake City, Vancouver), and Japan(Sapporo and Nagano)[10].

As the participation in sport activities increases, local governments need to take the lead in constructing sport facilities to meet the demand for sport activities, but systematic investigation for the operation and management of sport facilities and finding improvement measures should precede the expansion of supply. Through this process, national and local governments need to come up with measures to resolve excesses and overlapping investments that could be caused by excessive competition to attract sports facilities that require a huge amount of money financed[25][43].

There are financial limitations to building all sports facilities in all local governments, and they also lack of professional management skills and spend a lot of money on personnel and maintenance costs per unit of facilities compared to integrated management of various facilities. To solve these structural problems, it is desirable to divide the nation into several areas and manage them in a unified manner by region by region. In particular, winter sport facilities which cost more to build and operate than summer sport facilities, can prevent unnecessary overlapping investments by creating strategic winter sports hub cities in small and medium cities, including some large cities, as well as building winter sports facilities there.

5.3. Multi-functional facility

The facilities built for mega-sport events shall be multi-functional spaces. That is, they should be places where sport activities can be done not only for some elite players but also for all public. These facilities can also be used as beneficial places to spend leisure time, thereby expanding opportunities for rest and entertainment for reproduction. Therefore, sport facilities should be able to relieve stress in a healthy and productive manner and perform various functions such as being used as a venue for various events [44]. Whether it is an upgraded existing facility or a new one for the mega-sport events, sport facilities could be multifunctional, such as a gym. Ice facilities do not need to be adapted for use after the event and require minimal adaptation. They are multifunctional because they can host cultural activities related to various ice skates, and can contribute to expanding sports opportunities not only for top players but also for the general public [17].

Attracting tourist is another way to use multi-purpose facilities built for the mega-sport events. The idea was probably first initiated in the scenic Holmenkolen Ski Jumping in Oslo, Norway. Other host cities are turning Olympic facilities into recreational sports parks such as Olympic Park in Lillehammer to provide various functions [45]. In addition, tourists from winter-free countries like Southeast Asia want to travel to sports facilities such as ski resorts built for mega-sport events, experience sports events, tour the facilities and more [46]. Therefore, when building sports facilities, it is necessary to consider creating amenities (lodging, restaurants, etc.) for tourists to be used for multiple purposes after the event.

Location selection is also very important to increase the sustainability of the facility. It is to construct in an area with a large floating population and easy access, or to select an area with future development plans, considering that many people will use it as a venue for participation in sports activities for leisure selection even after the event ends[19].

Finally, it should be constructed as a facility that is easily accessible to all, including infants, teenagers, women, the elderly, and the disabled, and available throughout the year. It should also be designed to take into account the eco-friendly environment as much as possible and relate to sports activities[14].

6. Conclusions and Suggestions

This study considered the cases of post-use of mega-sport event facilities and reviewed the plan for post-use of winter sports stadiums, and based on that, aimed to present strategic measures to maximize the post-utilization of sports facilities to increase the legacy of mega-sport events, especially winter sports events.

Thus, the following conclusions were obtained:

First, it is necessary to maximize variable elements in the stadium construction phase to enable the use of various facilities(multi-purpose complexes, multi-functional facilities, mobile facilities, etc.)

Second, to minimize the construction costs of sports facilities and avoid excess or redundancy, the distribution of sports facilities and the selection of sports hub cities should be made(selection and concentration considering sports events and venues)

Third, a construction plan to cover facilities targeting not only professional athletes and local residents, but also visitors and travelers is needed(overcoming the limitations of winter sports and demographic limitations of host cities, and reviewing the utilization of tourists).

Fourth, various programs related to winter sports need to be developed(increasing efficiency in the utilization of winter sports facilities, linking the cultural industry such as four-season entertainment and concert halls).

Fifth, they need to be commercialized for tourism(attracting foreign visitors and tourists through the development of various tourist products, such as sports experience and stadium tour).

Sports legacy is not a relic that is automatically left behind when a sporting event is held, but a deliberate product of the ongoing process of planning, practicing, and coordinating from a long-term perspective[9]. Accordingly, cities that wish to host mega-sport events should provide detailed explanations on how to create a sports legacy in the bidding file and ensure the implementation[20]. The value of successful sports legacy may be appreciated when it is supported by the strategic planning capability to present a sustainable role model through the establishment, implementation, evaluation, and preservation of appropriate organization and objectives[47].

Academic discussions on the use of the stadiums have been mainly focused on sports events such as the Summer Olympics, the FIFA World Cup, and the Asian Games, and access to winter sports events centered on the Winter Olympics is relatively sluggish(Alberts, 2011). While building safe and complete infrastructures and stadium facilities is also important to successfully host the upcoming winter mega-sport events, it is more urgent to come up with reasonable and comprehensive measures to maximize the post-utilization of these facilities as part of the success and development of sport legacy.

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8. Contribution

8.1. Authors contribution

	Initial name	Contribution
		-Set of concepts 🔽
		-Design 🗹
		-Getting results 🔽
		-Analysis 🔽
		-Make a significant contribution to
		collection $ abla$
		-Final approval of the paper 🗹
Author	SHB	-Corresponding 🗹
		-Play a decisive role in modification \square
		 Significant contributions to concepts, de- signs, practices, analysis and interpreta- tion of data
		-Participants in Drafting and Revising Papers $ abla$
		-Someone who can explain all aspects of the

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ARMS CONTROL in the Korean Peninsula: Opportunities and Limitations

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Abstract

The historic first US-DPRK summit on June 12, 2018 in Singapore raised expectation for the peace on the peninsula. And on September 18-20, 2018, the two Koreas held a summit in Pyongyang. Here, the two Koreas agreed to the September Pyongyang Joint Declaration on the implementation of the Panmunjeom Declaration concluded on April 27, 2018, which included practical measures for the expansion and development of inter-Korean relations. Also, as a subsidiary agreement, the agreement in the military sector for the implementation of the Panmunjom Declaration was signed. It includes measures to help mitigate military tensions and build trust between the two Koreas, and to reduce the risk of war on the Korean Peninsula. This is the 9.19 Military Agreement. However, such inter-Korean efforts have not shown any success since the second US-DPRK summit at Hanoi in February 2019. In this situation, this paper examines whether arms control on the Korean peninsula is possible, if it is possible what direction will be effective, and what problems will arise in the process. This study is of great significance because the two Koreas must build trust and arms control for peaceful unification.

[Keywords] Arms Control, National Security, Trust Building, Korean Peninsula, Peace Regime

1. Introduction

It is true that the atmosphere of peace on the Korean Peninsula, which was formed rapidly after the 2018 Pyeongchang Winter Olympics, gave hope to Korea and the international community. The historic first US-DPRK summit on June 12, 2018 in Singapore raised this expectation further. At the summit, the two leaders largely agreed on four things; establishing a new relationship, establishing a peace regime on the Korean Peninsula, denuclearization, and repatriating the dead for US military deaths.

Prior to the meeting between the US-DPRK, the leaders of the two Koreas declared to the world after the summit that a new era of peace has come to the Korean Peninsula through a joint declaration of Panmunjom. Declarations issued by the two Koreas included measures to alleviate military tensions and relieve war risks, halting mutual hostilities, creating peace zones in the DMZ, creating peace zones and preventing accidental collisions in the northern limit line of the West Sea, and occasional military talks between defense officials.

Afterwards, the two Koreas held the 8th Inter-Korean General Military Talks on June 14, 2018 to implement the Panmunjeom Declaration, and agreed to restore the 6.4 agreement to prevent accidental collisions on the West Sea and complete restoration of military communications lines in the East-West Sea region. Then, on June 25, the two sides agreed to normalize the common network of international commercial ships between military communication lines and security

ships in the East-West Sea region through inter-Korean communication working contacts. On July 31, the 9th military general-level talks were held for further discussions on the implementation of military agreements. The 40th military Working-level talks were held from September 13th to 14th 2018, and the mutual final position was confirmed and the text for the military agreement was coordinated in the talks.

On September 18-20, 2018, the two Koreas held a summit in Pyongyang. Here, the two Koreas agreed to the September Pyongyang Joint Declaration on the implementation of the Panmunjeom Declaration concluded on April 27, 2018, which included practical measures for the expansion and development of inter-Korean relations. Also, as a subsidiary agreement, the agreement in the military sector for the implementation of the Panmunjom Declaration was signed. It includes measures to help mitigate military tensions and build trust between the two Koreas, and to reduce the risk of war on the Korean Peninsula. This is the 9.19 Military Agreement. The September 19th Inter-Korean Military Agreement was reached through two inter-Korean summits, eight document exchanges, and a 17-hour marathon working meeting[1].

Of course, this is not the first time a military agreement has been held between the two Koreas. There are about 10 meaningful agreements made only after the 1990s. Among them, the Inter-Korean Basic Agreement, agreed in December 1991, suspends mutual defamation, destruction, subversion, compliance with the Armistice Agreement, the restriction of force using, the for-mation and operation of the Joint Military Committee for Inter-Korean Military Forces, and the notification and control of large-scale military movements and military exercises. And, it also included peaceful use of the DMZ and staged disarmament. In addition, the Inter-Korean Nonaggression Agreement, agreed in September 1992, prohibits the use of force in any form, prohibits the use of force, and prohibits the invasion, attack, occupation of the other jurisdiction, the suspension of armed forces and reconnaissance and the blockade of territorial waters and airspace. As such, the two Koreas have consistently concluded military agreements for peace, and this September 19 military agreement seems to be part of an effort to find a more concrete and actionable way rather than a new agreement.

However, such inter-Korean efforts have not shown any success since the second US-DPRK summit at Hanoi in February 2019. As we have seen before, despite many efforts and attempts, the arms control of the Korean peninsula has not achieved much visible results. In this situation, this paper examines whether arms control on the Korean peninsula is possible, if it is possible what direction will be effective, and what problems will arise in the process. This study is of great significance because the two Koreas must build trust and arms control for peaceful unification. To this end, first of all, the concept and type of arms control will be examined and the arms control policy of the Korean peninsula will be evaluated. These assessments include directions and limitations based on situational analysis.

2. The Concepts and Types of Arms Controls

The conceptual definition of arms control varies. According to the logic of Hedlley Bull, which emphasizes the necessity of arms readjustment as a precondition for the balance of power, international security is achievable only if there is a balance of powers, and arms control is required as a condition of balance of power[2]. In this context, A. Ferguson defined arms control as "a concept that includes several weapon enhancements to increase the stability of mutual inhibition from complete disarmament."[3]

On the other hand, there is an interpretation that arms control is focused on the management of military confrontation, with a focus on reducing war and other risks. T. Schelling described arms control as "a variety of forms to limit the possibility of war between potential states, their spread and destructive power in wartime, and military cooperation in peacetime to reduce the cost of political

and economic opportunity in times of war."[4] L. Bloomfield defined "an effort to reduce, eliminate or minimize the risks and burdens that can arise from arms races by stabilizing or institutionalizing them."[5]

There are also attempts to understand arms control from a security point of view. Hwang Jin-hwan defines it as to identify, limit, prohibit or reduce the construction, deployment, transfer, operation, and use of specific military forces through unilateral, bilateral or multilateral agreements to ensure military transparency and ultimately to achieve national security[6]. Yong-Sup Han defines "security attainment by reducing or weakening military threats through bilateral or multilateral negotiations in peace."[7]

The concept of arms control tends to use arms reduction, disarmament, and arms limitations indiscriminately, but in a strict sense it is a term that came after World War II. What was presented before arms control was the concept of 'arms reduction' or 'disarmament', which was defined in terms of idealism. However, the concept of disarmament, which aims to achieve peace through quantitative reduction of military power, did not alleviate nuclear competition between the US and Soviet Union but rather paradoxically pushed the international community into a spiral of arms buildup. Only after Mutual Assured Destruction(MAD) achieved the 'balance of fear', the US-Soviet Union were able to find ways to prevent mutual destruction through arms control and mutual agreement. In this situation, the realist position to achieve even small achievements emerged. The United States and the Soviet Union, while acknowledging their respective security motives, tried to prevent the vicious cycle of arms competition and the possibility of war by making the arms race between the two countries controllable and predictable. This has led countries to prefer 'arm control' over 'disarmament' in order to ensure the reality and utility of arms control.

As such, the concept of arms control in modern use encompasses "all mutual military cooperation activities aiming for military stability by securing military transparency and building mutual military trust and transparency rather than the concept of disarmament to eliminate weapons immediately." In other words, it is assumed that arms control should be pursued in the context of stabilizing the balance of power and reducing the temptation of war. In this sense, a term of arms control can generically include arms reduction, arms limitation, disarmament, arms management, confidence building measures(CBM), arms freeze. Here, armament reduction or arms reduction refers to the quantitative reduction of already built military forces, ie., weapons or troops in possession, and armament limitation means to limit the military power in a quantitative or qualitative manner. Disarmament refers to the complete dismantling of the military forces, and it can be said that the victorious country completely disarms the losing country. Armament management is a term commonly used in Japan, and it is not the result of finding a more neutral concept by using control or reduction to express a negative effect on the construction of military forces, but it is not a commonly used term. Building military confidence refers to all measures to reduce risk and facilitate crisis management by increasing the predictability of opponents' military actions, and freeze means stopping further development at the current level. In general, when the terms disarmament and arms control are used, although arms control is used as a broader concept encompassing disarmament, arms control is not a higher concept than disarmament. However, when using disarmament in a narrow sense to reduce military size, it can be said that arms control is a broader concept than disarmament.

There are three main purposes for arms control. First, arms control has the primary purpose of reducing war threats through 'strategic balance'. Unstable arms race raises the possibility of war. Thus, the purpose of arms control is to stabilize the arms race and increase military stability or strategic stability, thereby suppressing war. Second, reducing the magnitude of damage during a war is an important goal. If a war breaks out after arms control has taken place, it is possible that the war would be significantly less damaging than a war that broke out in the absence of arms control. Restricting the operation, deployment, and construction of military capabilities, which are instrumental to expanding violence, can also reduce war avoidance. Third, by reducing military expenditures through arms control, economic costs can be diverted to other purposes.

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Armament control for this comprehensive purpose can be classified into various horizontally and vertically. First, as a horizontal classification, arms control can be classified into various types according to the number of participating countries, weapon types, controlled objects, approaches, controls, and mandatoryness[8]. Second, the arms control by control subjects can be divided into five vertically; 'control of military force development, manufacture and possession', 'prohibition of military force use and experiment', 'prohibition and restriction on military force deployment', 'restriction of military force operation', and 'prohibition and control of international transfer.'

Third, arms control can be roughly divided into operational arms control and structural arms control. Operational arms control here means controlling the operation and deployment of military forces. This is an approach that considers many wars in the past to be caused by misunderstandings, miscalculations, and mutual distrust[7]. Thus, it suggests that the possibility of war could be reduced if we can increase transparency and predictability of military intentions by decreasing these causes of war. Operational arms control focuses on increasing predictability by demonstrating the lack of willingness to surprise attacks and war provocations by permitting the transparent disclosure and verification of military activities and military deployments to opponents. To this end, military operations will be exposed to the public to enhance transparency in military activities and to monitor each other to eliminate the possibility of surprise attacks. It also includes 'constrains measures' in operational arms control, which relocate forward deployed military forces to the rear, assuming that separating conflicting military forces from one another reduces the likelihood of surprise attacks and wars.

Structural arms control, on the other hand, refers to the control of the size and structure of military forces. It focuses on military build-up, limiting mobilization, restricting the use of specific weapons in specific regions, weapons production and transfer regulations[8]. This can include freezes, establishing ceilings and preventing arms build-up, restricting the use of certain types of weapons or firepower, and reductions in the disposal of certain percentages or quantities of weapons[7].

Fourth, arms control can be classified into three types; military confidence building, restriction measures(or military restrictions), and arms reduction. Operational arms control is divided into military confidence building and restriction measures, and arms reduction means structural arms control[7]. For example, in order for the two Koreas to end the arms race and enter into arms control and disarmament, this is a claim that "action for trust building" should be the first priority.

3. The Assessment of Arms Control in the Peninsula

3.1. The assessment of arms control environment

The arms control environment of the Korean Peninsula has the following characteristics in terms of threat perception between North and South Korea, North Korea's nuclear development, strategy and force structure, and security situation of Northeast Asia. These factors are increasing the need for arms control between the two Koreas, but the influence is in the direction of suppressing rather than promoting arms control.

First, the asymmetry of mutual distrust is at work between the two Koreas. The most important historical memory is the psychological asymmetry of the Korean War[9]. The historical memory of the war left a deep rooted distrust that could not be resolved between the two Koreas, which made the disarmament proposal of the other side recognize as a peaceful offensive in terms of political propaganda. As a result, both political and military leaders became aware of a negative culture of arms control and realized that arms control was just a trick to deceive. The ideological confrontation between the two Koreas, which continues even after the end of the Cold War, has hindered the building of confidence. If the situation changes despite the temporary inter-Korean reconciliation, it has a sensitive influence on the inter-Korean relations and arms control negotiations.

Second, asymmetry of threat perception works between the two Koreas[10]. South Korea regards North Korea as the biggest threat, but North Korea sees the US as its main threat rather than South Korea. This makes the approach of conventional arms control between the two Koreas virtually difficult. In other words, since North Korea recognizes the US military capabilities as a core threat, it has consistently focused on disarmament measures, including the phased withdrawal of US troops. On the other hand, South Korea recognizes North Korea's surprise attack and the threat of the Seoul metropolitan area as its main threats, and has focused on building confidence between two Koreas[9]. Moreover, the two Koreas take a different approach to arms control, creating mutual distrust. South Korea sees arms control as a means of peace settlement, while North Korea is suspected of its intention to use it as a means of reunification under communism after the withdrawal of US forces.

Third, there is geo-strategic asymmetry between the two Koreas. They have different geo-strategic locations in Seoul and Pyongyang, their respective capitals. Thus, the level and perception of vulnerability to the 'strategic center' of North and South Korea is significantly different. From the North Korean point of view, it is easy to use the threat to attack Seoul as political and military pressure, while in South Korea this acts as a fatal weakness. At the same time, there is an asymmetry between North and South Korean society. South Korea has a dense socio-economic network centered on the metropolitan area. If it implements operational armament control, such as relocating forward artillery and mechanized units to the rear or restricting training and deployment, this is likely to lead directly to disarmament. And, in the Seoul metropolitan area, there is not enough space to deploy troops, but also the social consultation process takes a long time. Thus, if the situation changes rapidly and needs to be restored, it is difficult to restore the military posture different from North Korea.

Fourth, there is asymmetry in military capabilities between the two Koreas. North Korea developed weapons of mass destruction, such as nuclear weapons and missiles, causing a serious imbalance in military capabilities between the two Koreas. In the conventional field, North Korea has a 'quantitative advantage' over South Korea, but South Korea has been offsetting North Korea's quantitative advantage as a 'qualitative advantage' in terms of conventional weapons. Due to the asymmetry of the military capabilities between the two Koreas, the priority required by each of the arms control is also different. South Korea has focused on North Korea's ability to threaten the Seoul metropolitan area and reduce weapons of mass destruction, while North Korea has focused on reducing South Korea's military modernization and weakening US influence. Above all, North Korea's nuclear development since the 1990s has caused US-DPRK conflicts and has resulted in the neglect of arms control negotiations and implementation between the two Koreas.

Lastly, the arms race in Northeast Asia, which is in progress around the Korean Peninsula, has further complicated conventional arms control between the two Koreas. It seems that the United States and China have not yet deviated significantly from the trend of maintaining the status quo on the Korean Peninsula, but recently China has been visualizing a move to expand their geopolitical interests on the Korean Peninsula. The US also seems to be re-examining the global strategic value of the Korean Peninsula in order to lead a long-term competitive system with China at the Indo-Pacific strategy[11]. In other words, the US and China are fiercely competing for the maintenance and expansion of influence by putting North Korea's denuclearization issue at the forefront. The traditional military arms control system between North and South Korea, which should be envisioned in the mid- to long-term, has to take into account the power structure surrounded peninsula, so it is inevitable to think about how to set appropriate arms control goals in relation to the proper power posture and scale.

3.2. Goals and approaches in arms control between two Koreas

Until now, the two Koreas had to face difficulties in the implementation phase despite a considerable agreement. Recently, in the September 19, 2018 Military Agreement, the two Koreas agreed mostly on agendas to be discussed by the Military Joint Committee. The specific implementation and verification of the agenda were all delegated to the Joint Military Commission, but it has not yet been held. In the past, the second meeting of the North and South Korean Defense Ministers was held in November 2007, but only the consensus on the need to establish trust and the need to hold a joint inter-Korean investigation committee was not implemented.

The reason why the agreement on arms control between the two Koreas goes to the implementation stage and suffers difficulties is because the approach to arms control between them is fundamentally different from each other. South Korea draws lessons from its European experience in conventional arms control, aiming at ultimate goals in national security, peace coexistence and peace unification[12]. With these lessons, it has focused on building inter-Korean military trust, preventing war due to misunderstandings and miscalculations, preventing surprise attacks and possible all-out wars, and asymmetric disarmament to reduce North Korea's dominant power[7]. South Korea puts emphasis on establishing trust as a preliminary step toward arms control, assuming that North Korea's intention to invade will remain unchanged. Thus it has taken a step-by-step approach; "trust building and reducing tension \rightarrow Improving inter-Korean relations and implementing military trust \rightarrow Restriction and reduction of military power \rightarrow Peace coexistence system established."

On the other hand, North Korea has continuously insisted on reducing military spending on the Korean Peninsula by strengthening its military power and making the withdrawal of the USFK as its primary precondition. In other words, North Korea intends to use the arms control as a mechanism to remove the US influence on the Korean Peninsula, reduce and withdraw US military forces, weaken and eliminate US nuclear deterrence, and maintain its superiority over South Korea[7]. In addition, North Korea attempted to ameliorate the strategically disadvantaged situation by using a nuclear development card, and in this regard, it succeeded in exchanging the team spirit practice with the nuclear card in 1991. As such, North Korea is believed to have been using arms control as a means of earning time and achieving their security interests while temporarily holding offensive military policies when the situation becomes unfavorable.

It is estimated that the difference between North and South Korea's views on arms control and its approach has not changed since the 2000s. Even after the 2000s, the gap between the two Koreas did not narrow in terms of issues related to the peace agreement, USFK, and trustbuilding measures linked to conventional arms control. First of all, with regard to the peace regime, South Korea actually showed that it could be concluded under peace conditions, but North Korea has argued to replace the Armistice Agreement with the Peace Agreement between the US and DPRK.

In addition, the perception of the status and role of the USFK was also different. South Korea has a position that the existence of the USFK is essential as long as a security threat exists and the issue of the withdrawal of USFK is a problem to be resolved between the alliance. On the other hand, North Korea insisted that the top priority of the policy toward the United States is to withdraw their troops stationed in South Korea[7].

Under this perception, South Korea, as an approach to establishing military trust, emphasizes ties with political, economic, social, and cultural exchange and cooperation to ease tensions on the Korean Peninsula and solidify peace. However, North Korea first signed a peace agreement between the United States and North Korea and insisted that it should establish military trust between the two Koreas after the military security is secured. In the conventional arms reduction issue, South Korea maintained the principle of resolution between the two Koreas, while North Korea continued to condemn the US "isolation policy" and attempted to link it with the withdrawal of the USFK.

3.3. Limitations of arms control in the peninsula

The existing arms control policy that has been implemented between the two Koreas has several problems in terms of approach. First, based on their experiences, there have been a number of limitations in the role and function of conventional arms control between North and South Korea. Despite many agreements, South Korea has not been able to use it as a sufficient mechanism to deter North Korea's military provocations through conventional arms control efforts. In the 1990s and 2000s, North Korea launched military provocations against South Korea to achieve their political goals, and strained the South Korean government and the military. Nevertheless, South Korea is considered to have constituted an arms control policy with theoretical and ideal contents and systems, while overlooking the realistic conditions affecting it. In addition, although South Korea's arms control policy varies depends on the government, it has shown an error that tends to aim at itself rather than as a means to achieve the goal.

Meanwhile, it is true that South Korea brought excessive expectations and optimism to the functions and roles of conventional arms control, including building military confidence, to provide a breakthrough in improving inter-Korean relations in the face of intense tensions. However, the reality has not reached the most basic goal of arms control, which is to prevent military conflict.

Second, North Korea's ongoing nuclear development ambitions make it difficult to control arms. Although the 1991 Fundamental Agreement between two Koreas contains an agreement on innovative and comprehensive arms control measures, the crucial factor that has not been implemented to date is due to the North Korean nuclear issue. This is also the reason why arms control efforts and agreements have been delayed in the 2000s. South Korea's arms control is based on the dual attitude that conventional arms control is a matter that is dealt with between North and South Korea and nuclear arms control between North America. South Korea had the intention of establishing conditions for the peace regime on the Korean Peninsula while leading South Korea in terms of conventional arms control. But this effort led to a deadlock due to conflicts and tensions between North Korea and the US over denuclearization. In fact, the North Korean nuclear issue has had a decisive effect on the negotiations and implementation of arms control between the two Koreas. Therefore, from the first North Korean nuclear crisis in the 1990s to the second crisis in the 2000s, and until Kim Jong-un came to power in 2012, it has been recognized that progress in arms control cannot be expected without solving the North Korean nuclear development problem.

Third, South Korea has not been able to properly use the difficult internal and external security environment facing North Korea since the 1990s. North Korea has been assessed as having no opportunity to rebuild its own national economy without external capital and technology investments before and after the hardships of the 1990s. In the midst of this, the North Korean regime desperately felt threats within the system, such as the struggle for power and the relaxation of the social system. In this regard, it also used a survival strategy to divert the internal threat to the outside by inflating the external threat excessively. For example, North Korea insisted that its military build-up is a legitimate self-defense measure against external threats, and that the increase in armament, including nuclear weapons, is the only way to abandon US hostile policies to crush them.

Even in the Kim Jong-un era, North Korea emphasized the nuclear-economic virtuous cycle on the front while claiming the 'Byeong Jin'(应進) Policy which is nuclear and economy could be developed simultaneously. Of course, in reality, the economic-security dilemma was invited to deepen. In order to take advantage of this dilemma in South Korea's arms control, it seems that South Korea has attempted to use the arms control issue as a leverage for negotiations in terms of national security strategy. However, such efforts have failed to show great results, because of

interlocking with the structure of international relations surrounding North Korea's survival, suspicion of the North Korean regime, unilateral nuclear upgrade policy, and South Korea's inconsistent North Korea policy.

4. Conclusion

Negotiations to denuclearize the Korean Peninsula are still stagnant. On October 5, 2019, North Korea and the United States said they would resume negotiations, but they did not achieve much. In fact, there are both positive expectations and negative concerns about negotiations. However, one thing that is clear here is that everyone who makes such predictions admits that it is the most desirable way for the Korean peninsula to go beyond trust-building and to settle in peace. From this point of view, the 9.19 military agreement, which has achieved a series of results, can be said to be more meaningful than any other agreement ever signed between the two Koreas. GPs on both sides of the north and south were destroyed, and the symbol of division, JSA, was disarmed. And since the agreement, there has been no conventional military conflict between the two Koreas. If the agreement could be implemented and verified 100%, the possibility of an accidental collision between the two Koreas would almost disappear.

However, it is true that the progress of the military agreement between North and South Korea is currently being influenced by negotiations between the North and the US. As mentioned earlier, the conventional arms control currently being pursued by North and South Korea is closely related to nuclear negotiations between North America. In other words, North Korea and the United States are pursuing nuclear negotiations, and South and North Korea are pursuing conventional arms control, so North Korea has no choice but to link them. Therefore, Korea is forced to admit it.

In this situation, South Korea needs to establish clear standards and a strategic approach for the future arms control. In other words, it is necessary to promote arms control from a longterm and complex perspective. Of course, pursuing arms control should not weaken military power, but should be paralleled with building military power for the future.

Also, rather than narrowing the issue of the Korean Peninsula to the problems of the North and South Koreas, it will be necessary to promote arms control at the regional level and further try to establish a regional multilateral security system.

In order to more effectively implement the current stagnant 9.19 military agreement in more detail, it is necessary to organize the inter-Korean joint military committee as a top priority to promote the implementation of the agreement. In addition, measures should be taken to ensure that the implementation of military agreements is institutionalized. At the same time, it will be necessary to recognize that the implementation of the South-North Korea military agreement is not just a matter of inter-Korean relations, and to derive the role of the United States and even China, and demand implementation. This process could eventually have a positive effect, dispelling concerns over the inter-Korean military agreement.

Looking back at the history, the question "Can we really trust the Kim Jong-un regime in North Korea?" still remains deep. However, we all know that if we can solve the problem on the Korean Peninsula peacefully, that is the best way. It is also because we know peace using force is hurting us too much. Therefore, we need to find a way to make the peaceful process that has begun now a more meaningful outcome, and we need to try to do so. One important point here is that the defense should always be prepared. Because it can settle peace faster and make it stronger.

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6. Contribution

6.1. Authors contribution

	Initial name	Contribution
		-Set of concepts 🔽
		-Design 🔽
		-Getting results 🔽
		-Analysis 🔽
		-Make a significant contribution to
		collection \checkmark
		-Final approval of the paper $\ oxtimes$
Author	PGY	-Corresponding 🔽
		-Play a decisive role in modification \square
		 Significant contributions to concepts, de- signs, practices, analysis and interpreta- tion of data
		-Participants in Drafting and Revising Papers $ abla$
		-Someone who can explain all aspects of the
		paper 🗸

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