

Physiological approach to measuring the degree of excitement of spectators

— The Sasakawa Cup 2nd Global Youth Table Tennis Championships —

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Purpose

The International Table Tennis Federation (ITTF) is currently considering modifications to the conventional table tennis rules. An experiment, the results of which this article reports, was conducted in order to provide a primary data set for the discussion; the goal was to determine the factors at work when spectators get excited or thrilled at table tennis matches. For this purpose, physiological indicators, i.e. blood pressure and heart rate, were adopted as measures of the degree of excitement on the part of spectators. The stage of the experiment was the Sasakawa Cup 2nd Global Youth Table Tennis Championships, where altered rules were adopted experimentally.

Methods

The experiment was conducted at the Tokyo Metropolitan Gymnasium, Tokyo, Japan on 11 and 12 January, 1994, when the Sasakawa Cup Championships were being held. The experimentally altered rules included 11 point games with 5-game matches for team players and 7-game matches for individual players, and service change after each service.

As physiological indicators of the excitement on the part of spectators, heart rate (precordial leads) and blood pressure (sedentary position) were measured. For the measurement of heart rate, HEART RATE MEMORY, manufactured by NA MAC VINE, was used; for the measurement of blood pressure, STBP680 and STBP780, manufactured by NIPPON COLIN Ltd., were used.

Two high school students and four university students (male Japanese) cooperated as subjects for the experiment. The age, height, and weight of the subjects were 20.3 ± 2.1 yrs., 169.8 ± 3.72 cm, and 62.2 ± 7.88 kg, respectively (mean \pm S.D., $n=6$).

The subjects were chosen on the grounds that they knew neither conventional rules of table tennis nor the altered trial rules. However, the two high school students had belonged to a table tennis club during their first year at school; and one of the university students had taken a table tennis course for general students at the university.

During the two days of the experiment, the subjects were allowed to commute to the gymnasium from their home or boarding house, instead of being confined in ad hoc accommodations; nothing was done to control sleeping hours or diets of the subjects. They were required to report to the gymnasium, or the site of the experiment, at 8:00 am on the first day and at 10:30 am on the second day.

On the first day a detailed explanation as to the purposes of experiment was given to the subjects and their consent was obtained. At the beginning of the experiment each subject was requested to fill in a questionnaire. Each subject was equipped with an Electro-Cardio-Graph (ECG) electrode on the chest. The heart rate of four subjects was taken every ten seconds; that of the other two was taken every sixty seconds (one minute). The subjects were seated in an area reserved for them only, where they could not be disturbed by ordinary spectators or others. All data were taken when the subjects were seated at this site, close to the side of one of the main tables where they could watch the matches in front of them. Control data and body (oral) temperature data were taken before and after each match when the subjects were at rest with the eyes closed. The temperature and relative humidity in the gymnasium were controlled between 24 to 26°C and between 45 to 50 %, respectively. It was arranged that the subjects should not be disturbed by ordinary spectators or others. Those data which were taken while the subjects were napping, or chatting with one another were taken out of statistical analysis. A subjective index of "the Degree of Perceived Excitement" (DPE) was introduced as also representing the degree of excitement on the part of spectators. The index is based upon a questionnaire which each subject fills in while his impression of a match is still fresh; in the questionnaire, each match is to be ranked as either "not exciting at all", "hardly exciting", "neutral", "exciting", or "very exciting" in order of increasing DPE.

Results and discussions

1) Body temperature:

Table 1 shows the body temperature. Here it must be noticed that in data taken on the first day the highest temperature is recorded earliest in the day (10:40). This is a strange phenomenon in consideration of its typical circadian rhythm: body temperature fluctuates over a period of twenty-four hours, being lowest when one awakens in the morning; then it rises rapidly ("morning rise"), and reaches its plateau; after reaching its height at 4 pm + 1.5 hours, it begins to fall ("evening fall"). Although this periodic fluctuation in body temperature is natural to human beings, the above data do not behave quite the same way, the earliest temperature being the highest. The fact that this was the first time for the subjects to wear an ECG electrode must be a cause of this anomaly; moreover, not having established "rapport" with the staff and being exposed at the center of the hall to the eyes of many people around them, the subjects must have experienced mental stress, which was presumably severe enough to push up their body temperature. But judging from the behavior of body temperature after the earliest value (from "morning rise" through its height around 4 pm (17:33) to "evening fall"), the subjects got adjusted to the circumstances fairly soon once the experiment had started. On the second day the behavior of body temperature showed a very good agreement with the natural "circadian rhythm", suggesting that the subjects were in a desirable condition for the experiment from the very beginning.

2) Heart rate and blood pressure:

The data of heart rate and blood pressure taken during the two days of the experiment have been analyzed statistically in comparison with control data taken in the same period; although only a small fraction of the data can be introduced here owing to the limited paper space, the result can be interpreted here. The results suggest that heart rate measured every ten seconds is a good indicator of spectators' excitement, while heart rate measured every minute did not provide significant information: heart rate measured every ten seconds tended to show a good agreement with the DPE or questionnaire data (table 3), although there were some cases in which the DPE suggested "very exciting" or "exciting" while physiologically no excitement was detected. This gap between DPE and physiological indicators appears to have been caused by the difference in the attributes that those indicators reflect: The DPE, or the subjective impressions of the subject spectators, tends to reflect the acuteness of the excitement; on the other hand physiological indicators, i.e. blood pressure and heart rate, tend to reflect the duration of the excitement. The result of this particular experiment implies that physical indicators take a relatively longer excitement to be significantly affected. This suggests that a combination of DPE and physiological indicators will enable us to examine and classify the excitement of spectators into three or four degrees:

When both DPE and physiological indicators suggest excitement,

the excitement is acute and long-lasting.

When only DPE suggests excitement,

the excitement is acute but fleeting.

When only physiological indicators suggest excitement,

this can be considered to fall under the first category, just escaping the subject's impression.

When neither suggests excitement,

no excitement is induced.

In this way, physiological indicators are promising in that they not only serve as independent indicators of the degree of excitement but also provide an approach to its measurement together with a subjective indicator like the DPE. Tables 2 and 3 show the heart rate and blood pressure data obtained on the second day during a semi-final and the finals. Changes of statistical significance in heart rate can be seen only in the semi-final, suggesting at least in this particular championships the semi-final match was not necessarily less exciting or thrilling than the finals from spectators' viewpoint. So there may be no justifying pricing tickets for the finals higher than those for the semi-finals. Last but not least, factors determining the excitement of spectators have been identified on the basis of both the questionnaire and physiological indicators:

- 1) long rallies
- 2) powerful, fast rallies
- 3) close games
- 4) highly skilled play or technique
- 5) personal or national attachment to a particular player
- 6) energetic, aggressive play
- 7) exquisite ball control
- 8) few easy errors (particularly in receiving a service)

This list is not comprehensive, nor is it much different from what has been pointed out empirically or intuitively. However, the physiological data of this experiment have made the list objective; without a control experiment to be conducted in the same manner

under the conventional rules, it is impossible to conclude the effect of the altered trial rules on spectators. Nonetheless it can at least be argued: In order to make table tennis a more attractive sport, it is desirable to modify the rules in a way that will fulfill as many factors in the list as possible. But at the same time, the alteration must be done so as to prevent mere Fortune from determining the results of table tennis matches.

Summary

This is an elementary study on the degree or rate of excitement on the part of the spectators of table tennis. In this particular experiment, a combination of subjective data and objective, physiological data was adopted to measure the rate of excitement. Two high school students and four university students cooperated as subjects. This study was conducted with the purpose of providing a primary data set for the ITTF's discussion regarding the alteration of the conventional rules of table tennis. So the Sasakawa Cup 2nd Global Youth Table Tennis Championships, in which altered rules were adopted tentatively, was selected as the stage of the experiment. In conclusion, physiological data such as heart rate (beats per ten seconds) have proved to be promising objective indicators of the excitement induced in spectators: they tended to show a good agreement with subjective data obtained at the same time.

Table 1 Body Temperature (°C)

The First Day (11 Jan., 1994)

Subject	Time	10:40	11:57	15:47	17:33	19:24
1 T.M.		36.70	36.28	36.57	36.64	36.37
2 S.Y.		37.03	36.63	36.54	36.58	36.46
3 O.M.		36.70	36.54	36.56	36.82	36.70
4 Y.N.		37.23	37.05	37.16	36.88	36.84
5 Y.Y.		36.76	36.94	36.84	37.00	36.97
6 S.T.		37.55	37.28	37.26	37.06	36.80

The Second Day (12 Jan., 1994)

Subject	Time	12:42	14:53	15:40
1 T.M.		36.60	36.63	36.87
2 S.Y.		36.70	36.70	36.76
3 O.M.		36.97	37.41	36.78
4 Y.N.		37.45	37.04	37.19
5 Y.Y.		37.09	37.27	37.21
6 S.T.		37.25	37.11	37.12

Table 2 Youth Men's Singles Semi-finals and Youth Men's Singles Finals (Second Day, 12 Jan., 1994)

Upper = H.R. by 10 Seconds (S.D.)
 Lower = H.R. by 60 Seconds

Subject (Age)	Time	CONTROL1		YMS-SF		CONTROL2		3RD,4TH PLACE		YMS-F		CONTROL	
		12:42-12:48 n=36	13:27-14:10 n=258	13:27-14:10 n=258	14:50-14:57 n=60	14:50-14:57 n=60	15:00-15:17 n=102	15:10-15:37 n=162	15:50-16:00 n=60				
1 T.M. (21)	12.94(0.583) 77.6	12.33(0.901) 74.0	12.22(0.922) 73.3	12.02(0.954) 72.1	11.56(1.092) 69.4	11.47(0.947) 68.8							
2 S.Y. (22)	13.81(0.624) 82.9	13.78(1.112) 82.7	12.92(1.211) 77.5	12.84(1.167) 77.0	12.61(1.186) 75.7	13.03(1.104) 78.2							
3 O.M. (22)	12.81(0.668) 76.9	12.91(0.748) 77.5	11.82(0.725) 70.9	11.92(0.717) 71.5	11.53(0.940) 69.2	12.00(0.902) 66							
4 Y.N. (22)	15.75(0.604) 94.5	15.32(0.892) 91.9	13.78(0.904) 82.7	14.16(0.920) 85.0	14.03(0.845) 84.2	14.15(0.755) 84.9							
5 Y.Y. (18)	14.78(0.797) 88.7	14.16(0.915) 85.0	13.97(0.956) 83.8	14.00(0.808) 84.0	14.36(0.876) 86.2	13.38(0.922) 80.3							

Note
 YMS-SF: Youth Men's Singles Semi-Finals
 YMS-F : Youth Men's Singles Finals

Table 3 Youth Men's Singles Semi-Final and Youth Men's Singles Finals (Second Day, 12 Jan., 1994)

SEMI-FINAL									
Subject	Time	S.B.P. mmHg	D.B.P. mmHg	M.A.P. (mmHg)	Heart Rate (bpm)	Sample (n)	B.T. (°C)		
O.M.	13:27-14:10	135.2(6.42)	80.3(6.63)	98.6(5.52)	76.5(3.22)*	n=44	37.49		
	14:49-14:55	137.9(6.34)	85.096.88)	102.6(6.23)	71.1(2.85)	n=7			
Y.N.	13:28-14:09	132.2(5.97)	76.1(9.03)	94.8(6.59)	89.7(4.90)*	n=21	37.04		
	14:49-14:58	126.4(5.72)	74.2(5.07)	91.6(3.91)	80.8(3.52)	n=10			
FINAL									
Subject	Time	S.B.P. mmHg	D.B.P. mmHg	M.A.P. (mmHg)	Heart Rate (bpm)	Sample (n)	B.T. (°C)		
O.M.	15:03-15:38	136.0(5.08)	85.8(6.45)	102.6(4.90)	68.8(4.41)	n=32	37.49		
	14:49-14:55	137.9(6.34)	85.0(6.88)	102.6(6.23)	71.1(2.85)	n=7			
Y.N.	15:06-15:39	124.0(5.98)	72.9(5.25)	89.9(4.43)	81.2(3.99)	n=34	37.04		
	14:49-14:58	126.4(5.72)	74.2(5.07)	91.6(3.91)	80.8(3.52)	n=10			

Note

- S.B.P. : Systolic Blood Pressure
- D.B.P. : Diastolic Blood Pressure
- M.A.P. : Mean Arterial Pressure (1/3 of Pulse Pressure + D.B.P.)
- B.T. : Body Temperature