PRELIMINARY STUDY ON THE AGE ESTIMATION THROUGH A NEW SCORING SYSTEM OF TOOTH WEAR

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I. INTRODUCTION

The age is one of the important features to describe an individual physically[1]. So the age estimation may be the starting point for recognizing any individual.

The criteria for age estimation of an individual depends mostly on the factors such as body size, body weight, hair, teeth and skeletons. The appearance, possesions, and clothes could also be considered as factors for age estimation. Among these factors, teeth and skeletons are frquently used for age estimation, because they are changed less than any other factors.

Furthermore, tooth development follows certain pattern chronologically and provides information about the individual's degree of development or physical change at any given time. Therefore the evaluation of tooth enables the clinician to calculate an approximation of age of the individuals and the tooth can be used as a tool not only in age estimation but also in other fields of forensic dentistry[2-8].

The tooth wear can be described as being loss of surface material with tooth contact in abscence of caries and plagues[9]. An extremely worn dentition is uncommon in mordern population, because when it occurs, it is considered to be a great esthetic and clinical problems[10,11]. But gradual wear of incisal and occlusal surface of the teeth is a common and physical process. So many methods have been developed to use tooth wear for the chronological age estimation since the publication of Gustafson's scoring system[12]. Several improved methods and comparative studies have been reported in this field for age estimation[13-21].

Methods of age estimation based on the morphology of human adult teeth can be divided into scoring systems and direct measurement of age-related changes in the hard dental tissues[22]. But these systems for age estimation are designed mainly to use in skull samples to study about the ancient people[23]. In these systems, many factors can be considered and evaluated, such as the root translucency, the amount of alveolar bone resorption, the amount of secondary dentin deposition, the amount of cementum and so on. But these systems are limited in clinical use for age estimation in human beings because it is impossible to get the above informations without sacrificing the tooth. Therefore, the scoring system which has the high accuracy and reliability for age estimation in human beings is needed[24].

The purpose of present study are (1) to introduce a new scoring system of tooth wear which can apply to age estimation in human beings and (2) to suggest the linear regression equations which can be attained through a new scoring system of tooth wear for age estimation.

Ⅱ. MATERIALS AND METHODS

Subjects

The present study was based on the data from 389 individuals(231 males and 158 females) whose age range from 10 years to 70 years. The sexual and chronological distribution of the subjects was presented on Table Ⅰ. The individuals were examined clinically with regard to the health of teeth. Subjects who had no distinct malocclusion and filled teeth were selected.

[Table Ⅰ] Sexual and chronological distribution of the subjects.

Sex\Age	10-19	20-29	30-39	40-49	50-59	60-69	70-79	Total
Male	13	82	74	16	21	20	5	231
Female	12	76	35	15	14	4	2	158
Total	25	158	109	31	35	24	7	389

Methods

A set of maxillary and mandibular study casts were obtained from each individuals with an alginate impression in perforated metal stock trays.

Upper and lower permanent teeth except third molars were selected to examine the degree of tooth wear. The degree of incisal and occlusal wear was evaluated for each single tooth with naked eye or magnifying glass under a light using a new scoring system of tooth wear given in Table Ⅱ.

Statistical analysis

The data of each variables were inputed into an IBM personal computer and mean values and standard deviations of variables were attained using SPSS PC+(Microsoft Corp.). The analysis of variance(ANOVA) was performed to evaluate of the degree of tooth wear between

[Table Ⅱ] A new scoring system of tooth wear

Score	Incisors	Canine	Premolars	Molars
0	no visible wear			
1	P/S	P/S	1P/1S	1P/1S
2	B/T	B	2S/1B	2S/1B
3	Pc/Lc	Pc	3S/2B/1Pc	3S/4S/5S /2B/3B/1Pc
4	Sc	Sc	2Pc/1Sc	2Pc/1Sc
5		Bc	2Sc/1Bc	>3Pc/2Sc/1BC
6			>3Sc/>2B	>3Sc/>2Bc

P : point-like wear facet less than approximately 1mm in diameter

S : surface-like wear facet more than approximately 1mm in diameter

L : linear wear facet less than approximately 1mm in width

B : band-like wear facet more than approximately 1mm in width or wear facet involved more than 2 surfaces

T : the whole surface wear facet in incisal surface

Pc : point-like wear facet with the concavity less than approximately 1mm in diameter

Sc : surface-like wear facet with the concavity more than approximately 1mm in diameter

Lc : linear wear facet with the concavity less than approximately 1mm in width

Bc : band-like wear facet with the concavity more than approximately 1mm in width or band-like wear facet with the concavity involved more than 2 surfaces

* >3 Pc : more than three Pc
* 3S/2B/1Pc : 3S or 2B or 1Pc
* The concavity means the wear of dentin.
* In the situation that a tooth has several different degrees of wear, the highest degree of tooth wear should be selected for tooth wear score.

age groups. Student t-test and regression analysis were performed to examine the differences among variables.

Ⅲ. RESULTS

TableⅢ and Ⅳ show the mean values and standard deviations of the degree of tooth wear in males and females according to age groups.

There was a gradual increase of the degree of tooth wear for each tooth in males and females with aging. ($P<0.001$)

TableV shows the comparison of the degree of tooth wear for each tooth between males and females at each age groups. The sexual differences of the degree of tooth wear were shown in all teeth, and the degree of tooth wear in males was higher than that of females. ($P<0.05$)

The linear regression analysis for each tooth in males and females were shown in TableⅥ and Ⅶ. There was a moderate to high positive association between the subject's known age and tooth wear score through a new scoring system of tooth wear. The decision coefficient of posterior teeth were higher than those of anterior teeth. And the linear regression equations for each tooth were statistically significant. ($P<0.001$)

[Table Ⅲ] The Mean and S.D. of tooth wear score for each tooth according to age group in males.

	10−19	20−29	30−39	40−49	50−59	60−69	70−79
UR7	1.27±0.47	2.33±0.76	2.92±0.43	3.87±0.74	4.81±0.91	4.78±1.26	5.00±1.00
UR6	1.92±0.76	2.77±0.65	3.46±0.65	4.60±0.74	5.24±0.66	5.50±0.79	5.67±0.58
UR5	0.90±0.57	1.58±0.65	2.33±0.80	3.36±0.74	3.67±0.69	3.89±1.10	4.80±1.30
UR4	1.42±0.79	1.70±0.69	2.43±0.91	3.19±0.98	3.86±0.91	3.89±1.33	5.00±0.71
UR3	2.00±0.74	2.11±0.75	2.51±0.81	2.94±0.85	3.57±1.16	3.78±1.06	4.40±1.34
UR2	1.18±0.60	1.38±0.68	1.74±0.70	2.19±0.54	2.35±0.99	2.83±0.86	3.40±0.89
UR1	1.40±0.52	1.49±0.70	1.86±0.76	2.13±0.72	2.55±0.83	3.24±0.66	3.40±0.55
UL1	1.33±0.50	1.45±0.64	1.90±0.76	2.25±0.68	2.80±0.70	3.12±0.70	3.40±0.55
UL2	1.20±0.42	1.30±0.67	1.61±0.69	2.19±0.54	2.47±0.90	3.06±0.75	3.00±0.71
UL3	2.00±0.63	2.14±0.78	2.56±0.80	2.93±0.96	3.30±1.17	3.67±0.91	4.00±0.71
UL4	1.25±0.75	1.65±0.66	2.30±0.89	3.13±0.83	3.40±1.05	3.90±1.12	4.40±0.55
UL5	1.15±0.69	1.49±0.74	2.14±0.92	3.07±0.80	3.30±1.03	3.95±1.15	3.80±0.84
UL6	1.92±0.76	2.78±0.80	3.38±0.76	4.62±0.89	5.00±0.91	5.39±0.78	5.75±0.50
UL7	1.50±0.80	2.46±0.69	3.05±0.59	4.06±0.85	4.88±1.15	5.06±0.90	5.00±0.82
LL7	1.77±0.83	2.37±0.72	2.96±0.78	4.14±0.53	4.94±0.85	5.33±0.62	5.00±0.00
LL6	2.00±0.82	2.64±0.79	3.51±0.88	4.86±0.66	5.53±0.61	5.58±0.61	5.20±1.30
LL5	1.23±0.60	1.41±0.67	2.22±0.87	3.20±0.94	3.68±0.95	4.00±0.97	4.75±1.26
LL4	1.00±0.58	1.26±0.57	1.96±0.97	3.19±1.11	3.76±1.14	3.90±1.02	4.80±1.10
LL3	1.25±0.75	2.01±0.79	2.57±0.84	3.31±0.79	3.86±0.91	4.05±0.69	4.33±1.15
LL2	1.64±0.67	1.61±0.84	1.92±0.89	2.44±0.63	2.81±0.93	3.25±0.64	3.33±0.58
LL1	1.90±0.57	1.78±0.86	2.10±0.90	2.73±0.59	2.71±0.90	3.20±0.52	3.00±0.00
LR1	2.00±0.71	1.73±0.80	2.08±0.93	2.67±0.72	2.76±0.77	3.25±0.72	3.00±0.00
LR2	1.90±0.57	1.50±0.71	1.96±0.73	2.67±0.62	2.60±0.75	3.05±0.62	3.00±0.00
LR3	1.83±0.72	1.93±0.75	2.53±0.91	3.40±0.91	3.57±0.81	4.05±0.89	4.00±1.00
LR4	1.15±0.55	1.31±0.65	1.95±0.90	2.69±1.08	3.20±1.20	3.58±1.17	4.80±1.10
LR5	1.15±0.69	1.32±0.63	2.04±0.94	2.60±0.74	3.40±1.05	3.79±1.03	4.80±1.10
LR6	2.38±0.65	2.85±0.60	3.50±0.88	5.07±0.80	5.30±0.80	5.53±0.61	5.80±0.45
LR7	1.92±0.64	2.53±0.65	3.12±0.63	4.38±0.81	5.05±0.83	5.47±0.83	5.40±0.55

S.D. : standare deviation UL : upper left LL : lower left
UR : upper right LR : lower right

[Table Ⅳ] The Mean and S.D. of tooth wear for each tooth according to age group in females.

	10－19	20－29	30－39	40－49	50－59	60－69	70－79
UR7	2.08±1.00	2.20±0.72	2.08±0.63	3.53±0.52	4.54±0.78	4.00±0.00	5.00±0.00
UR6	2.50±0.90	2.65±0.53	3.24±0.61	4.38±0.65	4.93±0.73	4.00±1.41	5.00±0.00
UR5	1.25±0.87	1.33±0.78	1.94±0.68	2.71±0.47	3.71±0.61	3.67±1.53	5.00±0.00
UR4	1.08±0.67	1.59±0.66	2.09±0.85	2.93±0.26	3.29±0.83	2.50±0.58	4.50±0.71
UR3	1.58±0.67	1.89±0.72	2.06±0.81	2.80±0.56	3.21±0.58	3.00±0.00	5.00±0.00
UR2	1.11±0.78	1.21±0.70	1.41±0.71	1.93±0.59	2.23±0.83	2.25±0.50	3.50±0.71
UR1	1.00±0.82	1.30±0.57	1.50±0.72	2.31±0.63	2.62±0.87	3.00±0.00	4.00±0.00
UL1	1.10±0.88	1.27±0.61	1.52±0.62	2.14±0.66	2.69±0.85	3.00±0.00	3.50±0.71
UL2	1.00±0.53	1.14±0.51	1.39±0.67	1.93±0.59	2.00±0.91	2.00±0.82	3.50±0.71
UL3	1.58±0.79	1.89±0.72	2.14±0.77	2.93±0.59	3.07±0.73	3.00±0.00	5.00±0.00
UL4	1.40±0.52	1.53±0.74	2.26±0.89	2.93±0.96	3.29±0.73	3.25±0.96	3.50±0.71
UL5	1.09±0.70	1.28±0.75	1.89±0.80	2.87±0.74	3.29±0.73	2.67±0.58	4.00±0.00
UL6	2.67±0.49	2.67±0.66	3.06±0.60	4.00±0.65	4.93±0.73	4.00±0.00	5.00±0.00
UL7	1.83±0.83	2.28±0.73	2.80±0.47	3.60±0.91	4.38±0.77	3.67±0.58	4.00±0.00
LL7	2.27±0.65	2.29±0.72	2.67±0.60	3.50±0.52	4.86±0.77	4.00±1.00	5.00±0.00
LL6	2.36±0.50	2.76±0.59	3.24±0.61	4.14±0.53	5.21±0.70	5.00±1.41	5.00±0.00
LL5	0.91±0.54	1.31±0.68	2.06±0.74	2.67±0.62	3.64±0.74	3.50±0.71	4.50±0.71
LL4	0.91±0.54	1.19±0.59	1.57±0.78	2.67±0.62	3.43±0.76	3.00±0.82	3.50±0.71
LL3	1.80±0.79	1.73±0.75	2.06±0.73	3.00±0.53	3.07±0.83	3.50±0.58	5.00±0.00
LL2	1.75±0.89	1.32±0.77	1.76±0.70	2.23±0.83	2.50±0.76	2.50±1.00	4.00±0.00
LL1	1.56±1.01	1.46±0.85	1.83±0.79	2.79±0.80	2.64±0.93	2.75±0.50	4.00±0.00
LR1	1.50±1.07	1.58±0.79	1.71±0.79	2.71±0.61	2.71±0.73	3.00±0.00	4.00±0.00
LR2	1.56±0.88	1.30±0.64	1.73±0.67	2.57±0.76	2.57±0.76	2.75±0.50	3.50±0.71
LR3	1.40±0.84	1.84±0.81	2.06±0.73	3.15±0.69	2.79±0.80	3.67±0.58	4.50±0.71
LR4	0.75±0.62	1.13±0.55	1.40±0.60	2.29±0.47	2.71±0.91	2.67±1.53	4.00±0.00
LR5	0.50±0.52	1.19±0.63	1.53±0.62	2.14±0.53	3.08±0.76	3.00±1.00	4.50±0.71
LR6	1.91±0.83	2.77±0.57	3.09±0.63	4.36±0.74	5.15±0.69	5.50±0.71	5.50±0.71
LR7	2.09±0.94	2.27±0.75	2.94±0.56	3.73±0.70	4.93±0.92	4.67±0.58	5.00±0.00

S.D. : standard deviation　　UL : upper left　　LL : lower left
UR : upper right　　LR : lower right

[Table Ⅴ] Level of statistcal significance for comparison of the degree of tooth wear between males and females.

	Mean & S.D.(M)	Mean & S.D.(F)	F - value	Sig.
UR7	3.0063±1.207	2.7143±1.040	2.51	*
UR6	3.5251±1.228	3.1879±1.009	2.88	**
UR5	2.3562±1.204	1.8968±1.123	3.78	**
UR4	2.4865±1.250	2.0000±0.964	4.28	**
UR3	2.6171±1.056	2.1731±0.896	4.40	**
UR2	1.7955±0.886	1.4667±0.861	3.67	**
UR1	1.9352±0.902	1.5959±0.843	3.65	**
UL1	1.9579±0.895	1.5973±0.864	3.90	**
UL2	1.7419±0.886	1.3973±0.729	4.05	**
UL3	2.5946±0.988	2.1962±0.899	4.09	**
UL4	2.3540±1.169	2.0516±1.024	2.67	**
UL5	2.2115±1.212	1.8052±1.048	3.48	**
UL6	3.5113±1.267	3.1419±0.970	3.20	**
UL7	3.1455±1.219	2.7078±0.990	3.82	**
LL7	3.0892±2.254	2.7933±1.064	2.42	*
LL6	3.5905±1.390	3.2517±1.021	2.71	**
LL5	2.2523±1.251	1.8733±1.082	3.02	**
LL4	2.1441±1.354	1.6731±1.017	3.89	**
LL3	2.6295±1.129	2.1429±0.953	4.52	**
LL2	2.0543±0.985	1.7075±0.901	3.48	**
LL1	2.1864±0.935	1.8487±0.988	3.31	**
LR1	2.1727±0.949	1.8874±0.928	2.87	**
LR2	2.0046±0.861	1.7211±0.866	3.08	**
LR3	2.5867±1.107	2.1316±0.954	4.26	**
LR4	2.0398±1.227	1.4774±0.885	5.20	**
LR5	2.0969±1.234	1.5400±0.967	4.90	**
LR6	3.6933±1.278	3.2095±1.102	3.77	**
LR7	3.3108±1.254	2.8750±1.153	3.46	**

* : $P<0.05$　　** : $P<0.01$

[Table Ⅵ] The regression analysis for each tooth in males

	a	b	r	r^2	sig.
UR7	8.762	7.918	0.7749	0.6005	***
UR6	9.029	2.316	0.8076	0.6521	***
UR5	8.826	14.126	0.7518	0.5652	***
UR4	7.990	15.319	0.6986	0.4881	***
UR3	7.637	15.027	0.5670	0.3214	***
UR2	9.339	18.264	0.5826	0.3394	***
UR1	9.466	16.787	0.6050	0.3660	***
UL1	10.248	15.283	0.6457	0.4169	***
UL2	10.180	17.015	0.6436	0.4142	***
UL3	7.800	14.718	0.5453	0.2974	***
UL4	8.562	15.005	0.6997	0.4896	***
UL5	8.276	16.750	0.6994	0.4892	***
UL6	8.379	5.131	0.7590	0.5761	***
UL7	8.673	6.985	0.7709	0.5944	***
LR7	9.031	4.549	0.8185	0.6700	***
LR6	8.846	2.289	0.7949	0.6318	***
LR5	8.326	17.410	0.7244	0.5248	***
LR4	8.056	18.544	0.6950	0.4830	***
LR3	8.305	13.402	0.6563	0.4307	***
LR2	9.299	16.263	0.5759	0.3316	***
LR1	7.394	19.120	0.5013	0.2513	***
LL1	7.559	18.582	0.5024	0.2524	***
LL2	8.202	18.251	0.5748	0.3304	***
LL3	8.651	12.217	0.6966	0.4852	***
LL4	7.928	18.184	0.7509	0.5638	***
LL5	8.300	15.883	0.7454	0.5557	***
LL6	8.033	6.059	0.7846	0.6156	***
LL7	8.595	7.148	0.8040	0.6465	***

*** : $P<0.001$

$Y=aX+b$(Y : estimated age, X : tooth wear score)

r : corelation coefficient

r^2 : decision coefficient

[Table Ⅶ] The regression analysis for each tooth in females

	a	b	r	r^2	sig.
UR7	8.385	8.056	0.7325	0.5366	***
UR6	9.104	1.823	0.7625	0.5814	***
UR5	8.179	15.460	0.7580	0.5745	***
UR4	8.637	13.948	0.6783	0.4600	***
UR3	8.188	13.207	0.6046	0.3655	***
UR2	7.750	20.006	0.5133	0.2635	***
UR1	9.194	16.301	0.6456	0.4168	***
UL1	9.487	16.181	0.6501	0.4226	***
UL2	9.403	18.403	0.5506	0.3031	***
UL3	7.896	13.880	0.5781	0.3342	***
UL4	7.560	15.923	0.6295	0.3963	***
UL5	7.940	16.906	0.6864	0.4711	***
UL6	9.259	1.979	0.7377	0.5442	***
UL7	8.287	8.223	0.7041	0.4957	***
LR7	8.174	7.656	0.7708	0.5941	***
LR6	8.706	2.828	0.8024	0.6437	***
LR5	9.596	16.082	0.7596	0.5770	***
LR4	9.940	16.320	0.7240	0.5242	***
LR3	7.293	15.567	0.5730	0.3283	***
LR2	8.853	16.396	0.6161	0.3796	***
LR1	7.448	17.498	0.5604	0.3141	***
LL1	6.934	18.655	0.5558	0.3089	***
LL2	7.348	19.085	0.5343	0.2854	***
LL3	8.419	13.460	0.6522	0.4253	***
LL4	9.242	15.865	0.7632	0.5825	***
LL5	8.692	14.803	0.7811	0.6101	***
LL6	9.398	0.353	0.8003	0.6405	***
LL7	8.420	7.139	0.7695	0.5921	***

*** : $P<0.001$

$Y=aX+b$(Y : estimated age, X : tooth wear score)

r : corelation coefficient

r^2 : decision coefficient

Ⅳ. DISCUSSION

The age estimation of any individual is one of the most important subjects in various fields of the forensic dentistry. In the case of age estimation using teeth, various factors can be considered, such as tooth wear, alveolar bone resorption, secondary dentine formation, cementum apposition, root resorption, cervical dentine translucency, tooth eruption timing, mandibular change with aging, tooth color, and so on[10,25]. Among these factors, the tooth wear is usually used as a clinical tool for age estimation[8].

The degree of tooth wear can be influenced greatly by the tooth eruption timing[26,27], the amount of masticatory force of each tooth, the measuring method and so on. So many investi-

gators suggested various measuring methods for the degree of tooth wear, such as the 8-stage classification[28], the classification according to tooth wear type for each tooth[29], the classification using cusps[30], the classification of anterior tooth wear[31], the classification using the amount of enamel and dentine exposure[10] etc. But all of these systems have its limitations in clinical use for age estimation, because it is impossible to get any information without sacrificing the tooth.

In the present study, the tooth wear score was classified with 7-degrees depending on the pattern, number, position, and amount of tooth wear. Compairing with the other studies which observed the tooth wear depending on the amount of tooth wear only, the ratio of wear surface only, or scoring without consideration of kinds of tooth(the difference among incisors, canines, premolars and molars), a new scoring system of tooth wear considered four factors (pattern, number, position and amount of tooth wear) simultaneoulsy and suggested different criterias of scoring for incisors, canines, premolars and molars respectively.

Using a new scoring system of tooth wear, the degree of tooth wear were observed in each permanent teeth and at each age groups ranged from the 2nd decade of life to the 8th decade. According to the result of the present study, the degree of tooth wear increased at each tooth in males and females with aging, which agrees with the results of studies by Thoma[32], Doshihara[28], Lee[30], Yang[33], Lee[34], Ko[35], and Ekfelt[36]. It might be caused by increasing the loss of tooth surface with tooth contact with aging.

Comparing with the degree of tooth wear between males and femals, the degree of tooth wear in males is higher than that in females. This result agrees with those of studies of Thoma[32], Weinberg[37], Jonhanson[38], and Seligman[39]. They explained that males have the higher development of masticatory muscles than female, and also Shafer[40] and Lee[34] explained that male could exert stronger masticatory force than female.

The authors tried to attain the linear regression equations and decision coefficients between the tooth wear and aging. As presented on the table Ⅵ and Ⅶ, the linear regression equations attained in the present study are able to apply to the wide range of age from the 2nd decade of life to the 8th decade.

Decision coefficients were increased with aging. And this is considered that the tooth wear is the physical aging process depending on the chewing food. Therefore there is a consideration that the age estimation using tooth wear might be the higher clinical value in an advanced age group than in a young age group.

The authors observed the relationsips between the tooth wear and the aging process using a new scoring system of tooth wear. The results for age estimation using this scoring system in random samples are similar to admitted results of previous studies. A new scoring system of tooth wear is comparatively simple and easy to be applied to age estimation of an individual clinically at the wide range of age groups. Therefore a new scoring system of tooth wear could be more useful tool for age estimation than other previous scoring methods.

Futher large scale studies should be continued in order to increase the valus of this system as the clinical tool for age estimation.

Ⅴ. CONCLUSIONS

The authors evaluated the degree of permanent tooth wear in order to make the basic data that are necessary to estimate the age. 10443 teeth of 389 individuals with known age were selected to estimate the degree of tooth wear.

The obtained results were as follows ;

1. The degree of tooth wear was increased in males and females with aging. ($P<0.001$)
2. The degree of tooth wear in males is higher than that of females. ($P<0.05$)
3. The decision coefficient increased gradually from anterior teeth to posterior teeth.
4. The linear regression equations for individual teeth through a new scoring system of tooth wear were as follows :

Males

UR7 $Y=8.762X+7.918(r=0.7749)$
UR6 $Y=9.029X+2.316(r=0.8076)$
UR5 $Y=8.826X+14.126(r=0.7518)$
UR4 $Y=7.990X+15.319(r=0.6986)$
UR3 $Y=7.637X+15.027(r=0.5670)$
UR2 $Y=9.339X+18.264(r=0.5826)$
UR1 $Y=9.466X+16.787(r=0.6050)$
UL1 $Y=10.180X+15.283(r=0.6457)$
UL2 $Y=10.248X+17.015(r=0.6436)$
UL3 $Y=7.800X+14.718(r=0.5453)$
UL4 $Y=8.562X+15.005(r=0.6997)$
UL5 $Y=8.276X+16.750(r=0.6994)$
UL6 $Y=8.379X+5.131(r=0.7590)$
UL7 $Y=8.673X+6.985(r=0.7709)$

LR7 $Y=9.031X+4.549(r=0.8185)$
LR6 $Y=8.846X+2.289(r=0.74949)$
LR5 $Y=8.326X+17.410(r=0.7244)$
LR4 $Y=8.056X+18.544(r=0.6950)$
LR3 $Y=8.305X+13.402(r=0.6563)$
LR2 $Y=9.299X+16.263(r=0.5759)$
LR1 $Y=7.394X+19.120(r=0.5013)$
LL1 $Y=7.559X+18.582(r=0.5024)$
LL2 $Y=8.202X+18.251(r=0.5748)$
LL3 $Y=8.651X+12.217(r=0.6966)$
LL4 $Y=7.928X+18.184(r=0.7509)$
LL5 $Y=8.300X+15.883(r=0.7454)$
LL6 $Y=8.033X+6.059(r=0.7846)$
LL7 $Y=8.595X+7.148(r=0.8040)$

Females

UR7 $Y=8.358X+8.056(r=0.7325)$
UR6 $Y=9.104X+1.823(r=0.7625)$
UR5 $Y=8.179X+15.460(r=0.7580)$
UR4 $Y=8.637X+13.948(r=0.6783)$
UR3 $Y=8.188X+13.207(r=0.6046)$
UR2 $Y=7.750X+20.006(r=0.5133)$
UR1 $Y=9.194X+16.301(r=0.6456)$
UL1 $Y=9.487X+16.181(r=0.6501)$
UL2 $Y=9.403X+18.403(r=0.5506)$
UL3 $Y=7.896X+13.880(r=0.5781)$
UL4 $Y=7.560X+15.923(r=0.6295)$
UL5 $Y=7.940X+16.906(r=0.6864)$
UL6 $Y=9.259X+1.979(r=0.7377)$
UL7 $Y=8.287X+8.223(r=0.7041)$

LR7 $Y=8.174X+7.656(r=0.7708)$
LR6 $Y=8.706X+2.828(r=0.8024)$
LR5 $Y=9.596X+16.082(r=0.7596)$
LR4 $Y=9.940X+16.320(r=0.7240)$
LR3 $Y=7.293X+15.567(r=0.5730)$
LR2 $Y=8.853X+16.396(r=0.6161)$
LR1 $Y=7.448X+17.498(r=0.5604)$
LL1 $Y=6.934X+18.655(r=0.5558)$
LL2 $Y=7.348X+19.085(r=0.5343)$
LL3 $Y=8.419X+13.460(r=0.6522)$
LL4 $Y=9.242X+15.865(r=0.7632)$
LL5 $Y=8.692X+14.803(r=0.7811)$
LL6 $Y=9.398X+0.353(r=0.8003)$
LL7 $Y=8.697X+6.812(r=0.7538)$

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