Early detection for elderly people with musculoskeletal aging related diseases based on artificial intelligence model

Supplementary materials

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Supplementary Table1 Multi-dimensions features included in this study

Feature	Logistic	LASSO
Baseline		
Age	✓	
Height		✓
Weight	✓	
Body mass index	✓	✓
Systolic blood pressure		
Diastolic blood pressure		
Pulse pressure difference		
Heart rate		
Marriage status		
Education	✓	
Occupation type		
Gender		✓
How many people live together in your family?		
Nation		
Cognitive function		
MoCA questionnaire-Visuospatial/executive	✓	
MoCA questionnaire-Naming		✓
MoCA questionnaire-Attention		
MoCA questionnaire-Language		
MoCA questionnaire-Abstraction		
MoCA questionnaire-Delayed recall		
MoCA questionnaire-Orientation		
MoCA score		
Covid-19		
Have you been infected with Covid-19?		✓
How many times have you been vaccinated against COVID-19?	✓	
How many times have you infected COVID-19?		
Diet habit		
How much do you eat?	✓	✓
How often do you usually eat vegetables?	✓	
How often do you usally eat fruits?	✓	
How much do you eat meat per week?	✓	✓
How often do you usally eat eggs?		
How often do you usally drink milk?	✓	✓
How often do you eat soybean products?	✓	✓
How often do you eat seafood?	✓	
What kind of meat do you often eat?		✓
Disease history		
Is there a risk of dementia?		
Do you currently have a fracture?		
Do you have high blood pressure?		
Do you have diabetes?		✓
Do you feel any pain in your back?	✓	✓
Do you feel pain in your joints?	✓	
Do you feel hunched?	✓	
Do you fall often or are you worried about falling?	✓	
Have you lost more than 4 cm in height since the age of 40?	✓	
Whether you have comorbidities?		
Wether combined with endocrine disease?		
Whether combined with cardiac disease?		
Family history		
Family history of fracture, kyphosis, and osteoporosis in parents.		
Oral health		
Tooth loss		
Dental implant	✓	✓
Dental decay	✓	✓
How often do you brush your teeth?	✓	✓
How often do your gums bleed?	✓	
Do you have periodontal disease?	✓	
When was your last oral exam?	✓	✓
Have you had your teeth cleaned professionally recently?	✓	✓
Oral self-assessment?	✓	✓
Do you have a denture in your mouth?		✓
Have you had a oral ulcer in the last month?	✓	✓
Do you have regular oral check-ups?		
Physical activity		
How often do you participate in physical activity per year?	✓	
Time per physical activity.	✓	✓

Feature	Logistic	LASSO
How long have you participated in physical activity?	✓	
Have you plaed any sports in the past year?	✓	✓
Do you exercise less than 30 minutes a day?	✓	✓
EQ-5D		
Action capacity		✓
The ability to take care of yourself	✓	
The ability to perform daily activities		
The degree of pain or discomfort	✓	✓
The level of anxiety or depression	✓	
Grouping feature		
Grip	✓	✓
Bone mineral density mean value		
Bone mineral density T value	✓	✓
Bone mineral density Z value	✓	
Calf girth	✓	✓
SARC-F score	✓	✓
SARC-F: The difficulty of lifting/carrying a weight of 4.5kg.	✓	
SARC-F: The difficulty of crossing the room on foot,	✓	
SARC-F: Difficulty getting up from a bed or chair.	✓	
SARC-F: The difficulty of climbing stairs.	✓	
SARC-F: The number of falls in the past year.	✓	✓
Bone mineral density grouping	✓	
Calf girth grouping	✓	✓
Grip grouping	✓	✓
SARC-F grouping	✓	✓
Bone condition based on bone mineral density results.	✓	✓
Have you done any bone density examination?	✓	✓
Lifestyle		
How often do you usually cook at home?	✓	✓
The average time you spend indoors each day.	✓	✓
How oftern do you use kitchen hood when you cook?	✓	
How often do you participate in domestic work?	✓	
The floor you live on.	✓	
How often you climb up and down stairs (times/day)?	✓	
How much time do you spend using mobile phones, tablets and other electronic devices every day?	✓	✓
Is there a plastic bucket for daily drinking water?	✓	✓
Does your home use indoor air improvement measures?	✓	✓
How often do you smoke indoors in your home?	✓	✓
Does your home often dry sweep the floor?	✓	
Do you often fry food in your home?	✓	✓
Have you ever smoking ?	✓	
Do you smoke now?	✓	✓
Have you ever drinking?	✓	
Do you drink now?	✓	✓
When was your house last renovated?	✓	
Tea drinking?	✓	
Is there a plastic bucket for daily drinking water?		✓
Do you often drink drinks ?	✓	
Work environment.		
I often lose sleep because of the stress of work or life.	✓	
Do you have long periods of braking?	✓	
Do you use air condition in your home in winter?	✓	✓
Do you spend less than minutes a day outdoors, such as less than minutes of sunlight exposure, and do not take vitamin D supplements?	✓	✓
Do you regularly drink too much alcohol?	✓	
Mental health		
Are you satisfied with yourself?	✓	
Are you satisfied with your relationships?	✓	
Do you agree or disagree with the statement that I am very satisfied with my life?	✓	✓
Are you satisfied with the conditions in your place of residence?	✓	✓
I love my family very much.	✓	✓
Pharmacohistory		
Whether calcium has been or is currently being used?	✓	
Do you use air condition in your home in summer?	✓	
Have you used or are currently using regular vitamin D?	✓	
Whether active vitamin D has been or is currently being used?	✓	
Whether oral anti-osteoporosis drugs have been or are currently being used?		✓
Have you used or are currently using injectable anti-osteoporosis drugs?	✓	
Wether other drugs have been or are currently being used?	✓	
Do you not take any calcium supplements and avoid dairy products or are you allergic to dairy products?	✓	✓

Supplementary Table2 The annotation of features selected by Logistic regression, LASSO regression and XGBoost

Features

Categorical features

How often do you usually cook at home? (Cooking at home)

1=No cooking/occasionally; 2=once a day; 3=twice a day; 4=three times a day

How often do you usally drink milk? (Drinking milk)

1= ≤ two times/week; 2= three~six times/week; 3= ≥seven times/week

How much time do you spend using mobile phones, tablets and other electronic devices every day? (Electronic devices

1=≤1 hour; 2=2-3 hours; 3=4-5 hours; 4=6-7 hours; 5=8-9 hours; 6=≥10 hours

Dental implant

0= none; 1=1 tooth; 2=2 teeth; 3= ≥3 teeth

Dental decay

0= none; 1=1~4 teeth; 2=5-10 teeth; 3= ≥11 teeth

Have you had your teeth cleaned by a professional dentist recently? (Professional oral cleaning)

1= never; 2= more than two years; 3= two years; 4= one year; 5= six months; 6= one month

The number of falls in the past year. (Falls in the past year)

0=0 times; 1= 1-3 times; 2=≥4 times

Do you agree or disagree with the statement that I am very satisfied with my life? (Life satisfaction)

1= completely disagree; 2= disagree; 3= mildly disagree; 4= neither disagree nor agree; 5= mildly agree; 6=agree; 7=comp

The degree of pain or discomfort

1= no pain or discomfort; 2= a little; 3= moderate; 4= severe

Calf girth grouping[a]

0= normal; 1=abnormal

Grip grouping[a]

0= normal; 1=abnormal

SARC-F grouping[a]

0= normal; 1=abnormal

Bone condition based on BMD results. (BMD)[a]

 0=normal; 1=osteoporosis/osteopenia

Does your home use indoor air improvement measures? (Indoor air improvement)

0=no;1=yes

Do you drink now? (Drinking)

0=no;1=yes

Have you done any bone density examination? (Bone density examination)[a]

0=no;1=yes

Numerical features

Body mass index (BMI)

Grip[a]

The average time you spend indoors each day. (Time spent indoors)

Bone mineral density (BMD) T value[a]

Calf girth[a]

SARC-F[a]

[a.] these factors are the grouping features in this study.

Supplementary Table3 The feature composition of binary-classification models and multiple-classification models.

Model	General feature[a]	Grouping feature[b]	Number of features
Binary-classification			
Model_1	All	All	22
Model_2	All		13
Model_3	All	grip grouping	14
Model_4	All	bone density examination	14
Model_5	All	calf girth grouping	14
Model_6	All	SARC-F grouping	14
Model_7	All	bone mineral density	14
Model_8	All	bone mineral density、calf girth grouping	15
Model_9	All	grip grouping、calf girth grouping、SARC-F grouping、bone density examination	17
Model_10	All	grip grouping、calf girth grouping、SARC-F grouping、bone mineral density	17
Multiple-classification			
Model_11	All	All	22
Model_12	All		13
Model_13	All	grip grouping	14
Model_14	All	bone density examination	14
Model_15	All	calf girth grouping	14
Model_16	All	SARC-F grouping	14
Model_17	All	bone mineral density	14
Model_18	All	bone mineral density、calf girth grouping	15
Model_19	All	grip grouping、calf girth grouping、SARC-F grouping、bone density examination	17
Model_20	All	grip grouping、calf girth grouping、SARC-F grouping、bone mineral density	17

[a.] General features included cooking at home, drinking milk, electronic devices use time, dental implant, dental decay, professional oral cleaning, falls in the past year, life satisfaction, the degree of pain or discomfort, indoor air improvement, drinking, body mass index and time spent indoors.

[b.] Grouping features included calf girth grouping, grip grouping, SARC-F grouping, bone mineral density, bone density examination, grip, bone mineral density T value, calf girth and SARC-F score.

Supplementay Table4 The baseline information of bone and muscle condition

Features	Male	Female	Total	*P*-value
Calf girth grouping				***
Normal	197	169	366	
Abnormal	80	141	221	
Griping grouping				***
Normal	142	213	355	
Abnormal	153	98	251	
SARC-F grouping				0.3031
Normal	287	301	588	
Abnormal	25	36	61	
Bone condition grouping				*
Normal	88	68	156	
Osteoporosis / Osteopenia	39	58	97	
Muscle condition grouping				0.1387
Normal	132	150	282	
One index is abnormal	123	132	255	
Two indexs are abnormal	63	55	118	
Three indexs are abnormal	3	11	14	
Bone-muscle condition grouping				**
Normal / unknown	203	213	416	
Bone or muscle abnormal	204	186	390	
Bone and muscle abnormal	12	35	47	
Total	**419**	**434**	**853**	

"*" indicated the *P*-value was less than 0.05, "**" indicated the *P*-value was less than 0.01, "***" indicated the *P*-value was less than 0.001.

Supplementary Table5 The baseline information of subjects between training dataset and testing dataset

Feature	Training dataset N=682	Testing dataset N=171	*P* value
Grip[a]	25.66 ± 13.25	24.44 ± 15.61	0.35
Bone mineral density T value[a]	-1.01 ± 1.21	-1.16 ± 1.01	0.64
Calf girth[a]	34.71 ± 5.40	34.43 ± 6.68	0.06
Body mass index	24.71 ± 3.90	25.15 ± 4.86	0.56
Time spent indoors	12.51 ± 4.95	11.92 ± 5.20	0.16
SARC-F[a]			0.19
0	362	89	
1	182	41	
2	49	13	
3	24	8	
4	24	8	
5	22	5	
6	14	5	
7	5	0	
8	0	2	
Cook at home			0.31
No cooking/occasionally	145	44	
Once a day	71	20	
Twice a day	204	54	
Three times a day	262	53	
Drink milk			0.69
≤ two times/week	242	55	
three to six times/week	226	58	
≥seven times/week	214	58	
Electronic devices use time			0.24
≤ 1 hour	52	12	
2-3 hours	160	46	
4-5 hours	171	36	
6-7 hours	146	27	
8-9 hours	86	26	
≥10 hours	67	24	
Dental implant			0.07
None	485	104	
1-4 teeth	89	31	
5-10 teeth	45	17	
≥11 teeth	63	19	
Dental decay			0.09
None	433	106	
1-4 teeth	104	17	
5-10 teeth	11	2	
≥11 teeth	134	46	
Professional oral cleaning			0.07
Never	373	74	
More than two years	60	19	
Two years	67	21	
One year	58	13	
Six months	72	22	
One month	52	22	

Falls in the past year				0.30
0 times	365	94		
1-3 times	179	36		
≥4 times	138	41		
Life satisfaction				0.22
Completely disagree	137	48		
Disagree	3	0		
Mildly disagree	4	2		
Neither disagree nor agree	16	5		
Midly agree	32	4		
Agree	271	62		
Completely agree	219	50		
The degree of pain or discomfort				0.06
No pain or discomfort	301	64		
A little	69	11		
Moderate	43	10		
Severe	269	86		
Calf girth grouping				0.54
Normal	415	99		
Abnormal	267	72		
Grip grouping				0.29
Normal	412	95		
Abnormal	270	76		
SARC-F grouping				1.00
Normal	596	149		
Abnormal	86	22		
Bone mineral density				0.76
Normal	430	105		
Osteoporosis/osteopenia	252	66		
Indoor air improvement				1.00
No	555	139		
Yes	127	32		
Drinking				0.43
No	554	144		
Yes	128	27		
Bone density examination				0.41
No	456	108		
Yes	226	63		

Supplementary Table6 The performance of early detection models based on binary classification

No.	Genral feature[a]	Grouping feature	Type	Accuracy	AUC	95%CI	Sensitivity	Specificity	95%CI
Model_1	All	9	Training	1.00	1.00	-	1.00	1.00	0.9946-1.0000
			Testing	0.92	0.96	0.9333-0.9920	0.90	0.95	0.8735-0.9589
Model_2	All	0	Training	0.96	0.99	0.9903-0.9974	0.93	0.99	0.9412-0.9725
			Testing	0.70	0.77	0.6985-0.8407	0.65	0.74	0.6211-0.7638
Model_3	All	1	Training	0.99	1.00	0.9948-1.0000	0.98	0.99	0.9751-0.9939
			Testing	0.77	0.85	0.7913-0.9078	0.77	0.76	0.6954-0.8273
Model_4	All	1	Training	0.97	1.00	0.9950-0.9993	0.94	0.99	0.9516-0.9797
			Testing	0.71	0.77	0.7031-0.8422	0.64	0.78	0.6333-0.7745
Model_5	All	1	Training	0.99	1.00	0.9983-1.0000	0.99	0.99	0.9810-0.9968
			Testing	0.71	0.80	0.7332-0.8662	0.69	0.74	0.6394-0.7799
Model_6	All	1	Training	0.96	0.99	0.9897-0.9974	0.92	0.99	0.9412-0.9725
			Testing	0.67	0.78	0.7052-0.8451	0.63	0.71	0.5907-0.7368
Model_7	All	1	Training	0.97	1.00	0.9947-0.9993	0.94	0.99	0.9516-0.9797
			Testing	0.64	0.74	0.6614-0.8087	0.60	0.67	0.5606-0.7094
Model_8	All	2	Training	0.99	1.00	0.9973-1.0000	0.99	0.99	0.9790-0.9959
			Testing	0.80	0.85	0.7928-0.9089	0.78	0.81	0.7270-0.8531
Model_9	All	4	Training	1.00	1.00	0.9997-1.0000	1.00	1.00	0.9894-0.9996
			Testing	0.87	0.92	0.8756-0.9619	0.85	0.89	0.8117-0.9176
Model_10	All	4	Training	1.00	1.00	0.9998-1.0000	1.00	1.00	0.9919-1.0000
			Testing	0.84	0.91	0.8629-0.9519	0.80	0.87	0.7721-0.8884

[a.] General features included cooking at home, drinking milk, electronic devices use time, dental implant, dental decay, professional oral cleaning, falls in the past year, life satisfaction, the degree of pain or discomfort, indoor air improvement, drinking, body mass index and time spent indoors.

[b.] Grouping features included calf girth grouping, grip grouping, SARC-F grouping, bone mineral density, bone density examination, grip, bone mineral density T value, calf girth and SARC-F score.