

Supplementary Table 1. Number of samples and significant heritable genes.

Tissue	Abbreviation	<sup>a</sup> Sample Size	<sup>b</sup> Highly heritable genes
Brain Amygdala	AMY	120	1,192
Brain Anterior cingulate cortex BA24	ACC	137	1,248
Brain Caudate basal ganglia	CBG	174	1,573
Brain Cerebellar hemisphere	CEH	159	2,010
Brain Cerebellum	CER	190	2,606
Brain Cortex	COR	185	1,769
Brain Frontal cortex BA9	FRO	159	1,549
Brain Hippocampus	HIP	152	1,220
Brain Hypothalamus	HYP	158	1,220
Brain Nucleus accumbens basal ganglia	NAB	183	1,391
Brain Putamen basal ganglia	PBG	155	1,427
Brain Spinal cord cervical c-1	SCC	116	1,335
Brain Substantia nigra	SUB	102	1,092
Total		1,990	19,632

<sup>a</sup>Use only European samples; <sup>b</sup>The genes located in major histocompatibility complex (MHC) region were removed. The MHC region occurs on chromosome 6, between the flanking genetic markers *MOG* and *COL11A2* (from 6p22.1 to 6p21.3 about 29Mb to 33Mb on the hg38 assembly).

Supplementary Table 2. Significant TWAS genes for PD.

Gene	Chr	Gene Start	Gene End	Tissue	Best eQTL	TWAS Z-score	TWAS P-value	Permutation P-value
<i>LRRC37A2</i>	chr17	46511511	46555650	HYP	rs17689918	-9.63	6.12E-22	0.0256
				NAB	rs17762769	-9.40	5.62E-21	0.0061
				ACC	rs17689471	-9.30	1.44E-20	0.0373
				SCC	rs1396862	-9.29	1.59E-20	0.0027
				HIP	rs17763086	-9.23	2.62E-20	0.1430
				CEH	rs8072451	-9.23	2.79E-20	0.0429
				PBG	rs1396862	-9.22	3.06E-20	0.0033
				COR	rs17689824	-9.22	3.07E-20	0.0241
				CBG	rs171440	-9.20	3.46E-20	0.0241
				AMY	rs171440	-9.20	3.52E-20	0.0044
				CER	rs4566211	-9.02	1.82E-19	0.0030
				FRO	rs4566211	-9.00	2.18E-19	0.0432
				SUB	rs199443	-8.34	7.44E-17	0.0015
				<i>LRRC37A</i>	chr17	46292733	46337794	CER
SCC	rs17762769	-9.28	1.65E-20					0.0407
CEH	rs199449	-7.70	1.40E-14					0.3158
SUB	rs4277389	-7.57	3.65E-14					0.1188
<i>MMRNI</i>	chr4	89879532	89954629	AMY	rs35732828	-4.99	6.06E-07	0.4140
				FRO	rs3857059	9.34	9.49E-21	0.0916
				HIP	rs10021524	5.48	4.32E-08	0.0863
				SUB	rs1398946	5.43	5.51E-08	0.5217
				HYP	rs1442138	5.33	9.89E-08	0.1008
<i>ARL17A</i>	chr17	46516702	46579682	CEH	rs7683789	4.98	6.33E-07	0.0415
				PBG	rs17762769	-9.31	1.33E-20	0.0025
				AMY	rs17689471	-9.30	1.44E-20	0.0035
				NAB	rs199533	-9.12	7.74E-20	0.0075
				COR	rs199456	-8.95	3.48E-19	0.0043
				FRO	rs17689918	-8.85	8.41E-19	0.0063
				HYP	rs199536	-8.81	1.22E-18	0.0033
				CEH	rs8072451	-8.38	5.18E-17	0.0078
				CER	rs17689471	-8.38	5.20E-17	0.0158
				ACC	rs35937770	-7.84	4.55E-15	0.0119
				HIP	rs17689918	-7.18	6.83E-13	0.0577
<i>PLEKHM1</i>	chr17	45435900	45490749	CBG	rs17762769	-6.84	8.02E-12	0.0254
				CEH	rs17689918	8.94	3.76E-19	0.0001
				CER	rs171440	8.48	2.30E-17	0.0003
<i>FMNL1</i>	chr17	45221444	45247320	CER	rs17689471	8.65	4.95E-18	0.0007
				CEH	rs12449792	8.23	1.80E-16	0.0016
<i>CD38</i>	chr4	15778275	15853230	COR	rs1558451	-6.85	7.52E-12	0.0006
				PBG	rs13124087	-4.97	6.67E-07	0.0004
<i>RNF40</i>	chr16	30761745	30776307	CEH	rs7500719	-6.24	4.42E-10	0.1936

<i>SPPL2C</i>	chr17	45844835	45847072	CEH	rs199456	-6.00	1.98E-09	0.0541
				CER	rs3744760	-4.89	1.01E-06	0.0960
<i>VKORC1</i>	chr16	31090842	31095980	COR	rs8062719	5.95	2.66E-09	0.0176
<i>CCDC189</i>	chr16	30757423	30762710	COR	rs4889490	5.91	3.35E-09	0.0784
				NAB	rs1458201	5.59	2.23E-08	0.0569
<i>GPNMB</i>	chr7	23235967	23275108	AMY	rs6461687	5.84	5.31E-09	0.0031
				CER	rs199355	5.79	7.00E-09	0.0043
				PBG	rs6461687	5.76	8.47E-09	0.0095
				COR	rs156429	5.73	1.02E-08	0.0146
				CBG	rs2072369	5.61	2.02E-08	0.0036
				ACC	rs199355	5.55	2.87E-08	0.0149
				NAB	rs7796541	5.45	4.90E-08	0.0033
				HYP	rs7796541	5.00	5.66E-07	0.0039
<i>NUPL2</i>	chr7	23181827	23201011	CEH	rs7808488	5.69	1.24E-08	0.0096
				CER	rs7808488	5.65	1.65E-08	0.0146
<i>MAP3K14</i>	chr17	45263121	45317040	CER	rs9908905	5.51	3.52E-08	0.0001
<i>ZSWIM7</i>	chr17	15976560	15999717	CEH	rs4792721	-5.38	7.25E-08	0.0168
				FRO	rs2157991	5.20	2.04E-07	0.0625
				CER	rs1045599	-5.19	2.05E-07	0.0577
				CBG	rs758853	5.11	3.29E-07	0.0132
				NAB	rs9891938	5.03	4.80E-07	0.0800
				COR	rs178797	4.93	8.22E-07	0.0945
				ACC	rs2157991	4.89	1.01E-06	0.0225
<i>GAK</i>	chr4	849276	932373	CER	rs4974574	5.21	1.85E-07	0.0262
<i>CENPV</i>	chr17	16342534	16353656	FRO	rs8076864	4.99	6.07E-07	0.0001
<i>CPLX1</i>	chr4	784957	826198	CEH	rs1134921	-4.98	6.36E-07	0.0531

Note: HYP, Brain Hypothalamus; NAB, Brain Nucleus accumbens basal ganglia; ACC, Brain Anterior cingulate cortex BA24; SCC, Brain Spinal cord cervical c-1; HIP, Brain Hippocampus; CEH, Brain Cerebellar Hemisphere; PBG, Brain Putamen basal ganglia; COR, Brain Cortex; CBG, Brain Caudate basal ganglia; AMY, Brain Amygdala; CER, Brain Cerebellum; FRO, Brain Frontal Cortex BA9; SUB, Brain Substantia nigra.

Supplementary Table 3. Replication results of the conditionally independent genes.

Gene	Tissue	TWAS Z-score	TWAS P-value
<b>LRRC37A2</b>	HIP	-6.55	5.86E-11
	HYP	-6.41	1.41E-10
	NAB	-6.23	4.57E-10
	SUB	-6.23	4.61E-10
	ACC	-6.18	6.29E-10
	CEH	-6.17	6.70E-10
	CER	-6.11	9.85E-10
	PBG	-6.09	1.11E-09
	SCC	-6.08	1.19E-09
	CBG	-6.08	1.21E-09
	AMY	-6.08	1.23E-09
	COR	-6.01	1.80E-09
	FRO	-5.83	5.66E-09
	<b>MMRN1</b>	FRO	4.96
CEH		3.93	8.39E-05
HIP		3.91	9.30E-05
HYP		3.53	4.10E-04
PBG		3.04	2.34E-03
SUB		NA	NA
CD38	CEH	-3.12	1.79E-03
	PBG	-2.24	0.025
	COR	-2.17	0.030
	CER	-1.72	0.085
	FRO	-0.7	0.483
RNF40	CEH	-3.06	2.20E-03
<b>GPNMB</b>	ACC	3.82	1.32E-04
	PBG	3.78	1.54E-04
	CER	3.78	1.56E-04
	AMY	3.72	2.00E-04
	COR	3.67	2.46E-04
	HIP	3.63	2.85E-04
	CBG	3.44	5.72E-04
	NAB	3.05	2.30E-03
	HYP	2.5	0.012
	<b>ZSWIM7</b>	AMY	-3.44
CEH		-0.76	0.447
CER		-0.66	0.508
FRO		0.54	0.590
ACC		0.46	0.648
NAB		0.35	0.723
HYP		0.35	0.726
CBG		0.3	0.765

	COR	NA	NA
GAK	CER	2.08	0.037
<b>CPLX1</b>	CEH	-4.39	1.14E-05
	CER	-0.26	0.792

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Supplementary Table 4. The 122 GWAS summary data from other public resources.

Trait	Type	Sample Size (Cases)	URL/pmid
Life satisfaction (univariate)	Activities	80852	30643256
Types of physical activity in last 4 weeks: Heavy DIY	Activities	384450 (165465)	<a href="http://atlas.ctglab.nl/ukb2_sumstats">http://atlas.ctglab.nl/ukb2_sumstats</a>
Weekly usage of mobile phone in last 3 months	Activities	322862	<a href="http://atlas.ctglab.nl/ukb2_sumstats">http://atlas.ctglab.nl/ukb2_sumstats</a>
Duration walking for pleasure	Activities	323744	<a href="https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults">https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults</a>
Health satisfaction	Activities	150001	<a href="https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults">https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults</a>
Mineral and other dietary supplements: Glucosamine	Activities	454825 (88339)	<a href="https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults">https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults</a>
Types of transport used (excluding work): Walk	Activities	453928 (222804)	<a href="https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults">https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults</a>
Usual walking pace	Activities	453401	<a href="https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults">https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults</a>
Vitamin and mineral supplements: Vitamin C	Activities	453791 (39182)	<a href="https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults">https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults</a>
Overall health rating	Activities	454314	<a href="https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults">https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults</a>
Non-cancer illness code, self-reported: hypertension	Cardiovascular	289307	<a href="http://atlas.ctglab.nl/ukb2_sumstats">http://atlas.ctglab.nl/ukb2_sumstats</a>
Pulse rate (automated reading)	Cardiovascular	361411	<a href="http://atlas.ctglab.nl/ukb2_sumstats">http://atlas.ctglab.nl/ukb2_sumstats</a>
Hypertension	Cardiovascular	361141 (93560)	<a href="https://www.dropbox.com">https://www.dropbox.com</a>
Diagnosed by doctor: High blood pressure	Cardiovascular	455303 (122620)	<a href="https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults">https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults</a>
Systolic Blood Pressure (automated reading)	Cardiovascular	361402	<a href="https://atlas.ctglab.nl">https://atlas.ctglab.nl</a>
High blood pressure	Cardiovascular	458554 (144793)	<a href="ftp://ftp.ebi.ac.uk/pub/databases/gwas/summary_statistics">ftp://ftp.ebi.ac.uk/pub/databases/gwas/summary_statistics</a>
Resting heart rate	Cardiovascular	24218	<a href="ftp://ftp.ebi.ac.uk/pub/databases/gwas/summary_statistics">ftp://ftp.ebi.ac.uk/pub/databases/gwas/summary_statistics</a>
Fluid intelligence test - Fluid intelligence score	Cognitive	99739	<a href="http://atlas.ctglab.nl/ukb2_sumstats">http://atlas.ctglab.nl/ukb2_sumstats</a>
Intelligence	Cognitive	269867	<a href="https://ctg.cncr.nl/documents/p1651/SavageJansen_IntMeta_sumstats.zip">https://ctg.cncr.nl/documents/p1651/SavageJansen_IntMeta_sumstats.zip</a>
Verbal-numerical reasoning	Cognitive	168033	29844566
Cognitive performance	Cognitive	257828	<a href="https://www.thessgac.org/data">https://www.thessgac.org/data</a>
Fluid intelligence score	Cognitive	146808	<a href="https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults">https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults</a>
Maximum digits remembered correctly	Cognitive	89799	<a href="https://atlas.ctglab.nl">https://atlas.ctglab.nl</a>
Mean time to correctly identify matches	Cognitive	383748	<a href="https://atlas.ctglab.nl">https://atlas.ctglab.nl</a>
Lymphocyte count (three-way meta)	Immunological	171643	<a href="https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults">https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults</a>
Lymphocyte percentage of white cells (three-way meta)	Immunological	171748	<a href="https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults">https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults</a>
Mean corpuscular volume (three-way meta)	Immunological	172433	<a href="https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults">https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults</a>
Neutrophil percentage of white cells (three-way meta)	Immunological	171542	<a href="https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults">https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults</a>
Granulocyte count (three-way meta)	Immunological	169822	<a href="http://data.qld.edu.au/public/">http://data.qld.edu.au/public/</a>
Lymphocyte count (two-way meta)	Immunological	132452	<a href="ftp://ftp.sanger.ac.uk/pub/project/humgen/summary_statistics">ftp://ftp.sanger.ac.uk/pub/project/humgen/summary_statistics</a>

Lymphocyte percentage of white cells (two-way meta)	Immunological	132570	<a href="ftp://ftp.sanger.ac.uk/pub/project/humgen/summary_statistics">ftp://ftp.sanger.ac.uk/pub/project/humgen/summary_statistics</a>
Mean corpuscular hemoglobin (three-way meta)	Immunological	172332	<a href="ftp://ftp.sanger.ac.uk/pub/project/humgen/summary_statistics">ftp://ftp.sanger.ac.uk/pub/project/humgen/summary_statistics</a>
Mean corpuscular hemoglobin (two-way meta)	Immunological	132224	<a href="ftp://ftp.sanger.ac.uk/pub/project/humgen/summary_statistics">ftp://ftp.sanger.ac.uk/pub/project/humgen/summary_statistics</a>
Mean corpuscular volume (two-way meta)	Immunological	132353	<a href="ftp://ftp.sanger.ac.uk/pub/project/humgen/summary_statistics">ftp://ftp.sanger.ac.uk/pub/project/humgen/summary_statistics</a>
Mean platelet volume (two-way meta)	Immunological	127230	<a href="ftp://ftp.sanger.ac.uk/pub/project/humgen/summary_statistics">ftp://ftp.sanger.ac.uk/pub/project/humgen/summary_statistics</a>
Neutrophil count (three-way meta)	Immunological	170702	<a href="ftp://ftp.sanger.ac.uk/pub/project/humgen/summary_statistics">ftp://ftp.sanger.ac.uk/pub/project/humgen/summary_statistics</a>
Neutrophil percentage of white cells (two-way meta)	Immunological	132352	<a href="ftp://ftp.sanger.ac.uk/pub/project/humgen/summary_statistics/">ftp://ftp.sanger.ac.uk/pub/project/humgen/summary_statistics/</a>
Blood urea nitrogen	Metabolic	243031	31152163
Hip circumference	Metabolic	385887	<a href="http://atlas.ctglab.nl/ukb2_sumstats">http://atlas.ctglab.nl/ukb2_sumstats</a>
Impedance of leg (left)	Metabolic	379807	<a href="http://atlas.ctglab.nl/ukb2_sumstats">http://atlas.ctglab.nl/ukb2_sumstats</a>
Impedance of leg (right)	Metabolic	379813	<a href="http://atlas.ctglab.nl/ukb2_sumstats">http://atlas.ctglab.nl/ukb2_sumstats</a>
Leg fat percentage (right)	Metabolic	379806	<a href="http://atlas.ctglab.nl/ukb2_sumstats">http://atlas.ctglab.nl/ukb2_sumstats</a>
Waist-hip ratio	Metabolic	93480	<a href="http://portals.broadinstitute.org/collaboration/giant/index.php/Main_Page">http://portals.broadinstitute.org/collaboration/giant/index.php/Main_Page</a>
Waist-hip ratio (adjusted for BMI)	Metabolic	210086	<a href="http://portals.broadinstitute.org/collaboration/giant/index.php/Main_Page">http://portals.broadinstitute.org/collaboration/giant/index.php/Main_Page</a>
Waist-hip ratio (adjusted for BMI, female)	Metabolic	116742	<a href="http://portals.broadinstitute.org/collaboration/giant/index.php/Main_Page">http://portals.broadinstitute.org/collaboration/giant/index.php/Main_Page</a>
Body Mass Index	Metabolic	322154	<a href="http://portals.broadinstitute.org/collaboration/giant/index.php/Main_Page">http://portals.broadinstitute.org/collaboration/giant/index.php/Main_Page</a>
Body Mass Index (female)	Metabolic	171977	<a href="http://portals.broadinstitute.org/collaboration/giant/index.php/Main_Page">http://portals.broadinstitute.org/collaboration/giant/index.php/Main_Page</a>
Comparative body size at age 10	Metabolic	448349	<a href="https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults">https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults</a>
Arm fat-free mass (left)	Metabolic	379653	<a href="http://atlas.ctglab.nl/ukb2_sumstats">http://atlas.ctglab.nl/ukb2_sumstats</a>
Arm fat mass (left)	Metabolic	379663	<a href="http://atlas.ctglab.nl/ukb2_sumstats">http://atlas.ctglab.nl/ukb2_sumstats</a>
Arm fat percentage (left)	Metabolic	379663	<a href="http://atlas.ctglab.nl/ukb2_sumstats">http://atlas.ctglab.nl/ukb2_sumstats</a>
Arm fat percentage (right)	Metabolic	379663	<a href="http://atlas.ctglab.nl/ukb2_sumstats">http://atlas.ctglab.nl/ukb2_sumstats</a>
Body fat percentage	Metabolic	379615	<a href="http://atlas.ctglab.nl/ukb2_sumstats">http://atlas.ctglab.nl/ukb2_sumstats</a>
Impedance of arm (left)	Metabolic	379803	<a href="http://atlas.ctglab.nl/ukb2_sumstats">http://atlas.ctglab.nl/ukb2_sumstats</a>
Leg fat-free mass (left)	Metabolic	379766	<a href="http://atlas.ctglab.nl/ukb2_sumstats">http://atlas.ctglab.nl/ukb2_sumstats</a>
Leg fat-free mass (right)	Metabolic	379793	<a href="http://atlas.ctglab.nl/ukb2_sumstats">http://atlas.ctglab.nl/ukb2_sumstats</a>
Leg fat mass (left)	Metabolic	379783	<a href="http://atlas.ctglab.nl/ukb2_sumstats">http://atlas.ctglab.nl/ukb2_sumstats</a>
Leg fat mass (right)	Metabolic	379802	<a href="http://atlas.ctglab.nl/ukb2_sumstats">http://atlas.ctglab.nl/ukb2_sumstats</a>
Leg fat percentage (left)	Metabolic	379786	<a href="http://atlas.ctglab.nl/ukb2_sumstats">http://atlas.ctglab.nl/ukb2_sumstats</a>
Leg predicted mass (right)	Metabolic	379793	<a href="http://atlas.ctglab.nl/ukb2_sumstats">http://atlas.ctglab.nl/ukb2_sumstats</a>
Trunk fat mass	Metabolic	379578	<a href="http://atlas.ctglab.nl/ukb2_sumstats">http://atlas.ctglab.nl/ukb2_sumstats</a>
Trunk fat percentage	Metabolic	379600	<a href="http://atlas.ctglab.nl/ukb2_sumstats">http://atlas.ctglab.nl/ukb2_sumstats</a>

Whole body fat-free mass	Metabolic	379804	<a href="http://atlas.ctglab.nl/ukb2_sumstats">http://atlas.ctglab.nl/ukb2_sumstats</a>
Whole body water mass	Metabolic	379835	<a href="http://atlas.ctglab.nl/ukb2_sumstats">http://atlas.ctglab.nl/ukb2_sumstats</a>
Waist circumference	Metabolic	455545	<a href="https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults">https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults</a>
C-reactive protein	Metabolic	28520	<a href="ftp://ftp.ebi.ac.uk/pub/databases/gwas/summary_statistics">ftp://ftp.ebi.ac.uk/pub/databases/gwas/summary_statistics</a>
Cancer (diagnosed by doctor)	Other	385231	<a href="http://atlas.ctglab.nl/ukb2_sumstats">http://atlas.ctglab.nl/ukb2_sumstats</a>
Chest pain or discomfort when walking uphill or hurrying	Other	48190	<a href="http://atlas.ctglab.nl/ukb2_sumstats">http://atlas.ctglab.nl/ukb2_sumstats</a>
Educational attainment	Other	95427	<a href="https://www.thessgac.org/data">https://www.thessgac.org/data</a>
FEV1	Other	400102	<a href="http://data.qld.edu.au/public/Q1031/UKB_impute_v1/3063.v1.fastGWA.gz">http://data.qld.edu.au/public/Q1031/UKB_impute_v1/3063.v1.fastGWA.gz</a>
Male pattern baldness (BOLT LMM non-infinitesimal mixed model)	Other	205327	<a href="http://cnsgenomics.com/data/mpb/mpb_bolt_lmm_aut_x.tab.zip">http://cnsgenomics.com/data/mpb/mpb_bolt_lmm_aut_x.tab.zip</a>
Open-angle glaucoma	Other	22795	<a href="https://storage.googleapis.com/finngen-public-data-r2/summary_stats">https://storage.googleapis.com/finngen-public-data-r2/summary_stats</a>
Age at cancer diagnosis	Other	73638	<a href="https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults">https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults</a>
Bread type: White	Other	440084 (115996)	<a href="https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults">https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults</a>
Cereal intake	Other	435601	<a href="https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults">https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults</a>
Cheese intake	Other	64001	<a href="https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults">https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults</a>
Crohn's Disease	Other	69268 (22575)	<a href="https://www.ibdgenetics.org/downloads.html">https://www.ibdgenetics.org/downloads.html</a>
Fresh fruit intake	Other	440074	<a href="https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults">https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults</a>
Friendships satisfaction	Other	148842	<a href="https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults">https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults</a>
Hair colour (natural, before greying): Blonde	Other	385603 (43319)	<a href="https://atlas.ctglab.nl">https://atlas.ctglab.nl</a>
FVC	Other	400102	<a href="http://data.qld.edu.au/public/Q1031/UKB_impute_v1/3062.v1.fastGWA.gz">http://data.qld.edu.au/public/Q1031/UKB_impute_v1/3062.v1.fastGWA.gz</a>
Age first had sexual intercourse	Other	339614	<a href="https://atlas.ctglab.nl">https://atlas.ctglab.nl</a>
Job involves mainly walking or standing	Other	259397	<a href="https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults">https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults</a>
Hair/balding pattern: Pattern 1	Other	176380 (56514)	<a href="https://atlas.ctglab.nl">https://atlas.ctglab.nl</a>
Hair/balding pattern: Pattern 4	Other	176380 (32228)	<a href="https://atlas.ctglab.nl">https://atlas.ctglab.nl</a>
Never eat eggs, dairy, wheat, sugar: Wheat products	Other	384986 (10236)	<a href="https://atlas.ctglab.nl">https://atlas.ctglab.nl</a>
Number of self-reported cancers	Other	456269	<a href="https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults">https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults</a>
Type 2 Diabetes	Other	898130 (74124)	<a href="http://diagram-consortium.org/downloads.html">http://diagram-consortium.org/downloads.html</a>
Ulcerative colitis	Other	72647 (20417)	<a href="https://www.ibdgenetics.org/downloads.html">https://www.ibdgenetics.org/downloads.html</a>
Oily fish intake	Other	453893	<a href="https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults">https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults</a>
Long-standing illness, disability or infirmity	Other	377498 (122262)	<a href="https://atlas.ctglab.nl">https://atlas.ctglab.nl</a>
Bilateral oophorectomy (both ovaries removed) (female)	Other	205791 (16654)	<a href="https://atlas.ctglab.nl">https://atlas.ctglab.nl</a>
Education - Qualifications	Other	318526	<a href="https://atlas.ctglab.nl">https://atlas.ctglab.nl</a>



FEV1/FVC ratio	Other	79055	<a href="ftp://ftp.ebi.ac.uk/pub/databases/gwas/summary_statistics">ftp://ftp.ebi.ac.uk/pub/databases/gwas/summary_statistics</a>
Male pattern baldness (BOLT LMM infinitesimal mixed model)	Other	205327	<a href="http://cnsgenomics.com/data/mpb/mpb_bolt_lmm_aut_x.tab.zip">http://cnsgenomics.com/data/mpb/mpb_bolt_lmm_aut_x.tab.zip</a>
Offspring birthweight (maternal)	Other	86577	<a href="http://mccarthy.well.ox.ac.uk/publications">http://mccarthy.well.ox.ac.uk/publications</a>
PEF	Other	24218	<a href="ftp://ftp.ebi.ac.uk/pub/databases/gwas/summary_statistics">ftp://ftp.ebi.ac.uk/pub/databases/gwas/summary_statistics</a>
Gestational weight gain (maternal, total)	Other	10555	<a href="http://egg-consortium.org/downloads">http://egg-consortium.org/downloads</a>
Ease of getting up in the morning	Psychiatric	345552 (91820)	<a href="https://ctg.cncr.nl">https://ctg.cncr.nl</a>
General happiness	Psychiatric	126132	<a href="http://atlas.ctglab.nl/ukb2_sumstats">http://atlas.ctglab.nl/ukb2_sumstats</a>
Well-being spectrum	Psychiatric	2311184	30643256
Anxiety - Recent inability to stop or control worrying	Psychiatric	126300	<a href="https://atlas.ctglab.nl">https://atlas.ctglab.nl</a>
Current tobacco smoking	Psychiatric	455825	<a href="https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults">https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults</a>
Frequency of drinking alcohol	Psychiatric	147581	<a href="https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults">https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults</a>
Getting up in morning	Psychiatric	455090	<a href="https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults">https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults</a>
Happiness	Psychiatric	146970	<a href="https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults">https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults</a>
Been in serious accident believed to be life-threatening	Psychiatric	126665 (12432)	<a href="https://atlas.ctglab.nl">https://atlas.ctglab.nl</a>
Worrier / anxious feelings	Psychiatric	444404 (251982)	<a href="https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults">https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults</a>
Sleep duration (mean)	Psychiatric	384317	<a href="https://ctg.cncr.nl/documents/p1651/Sleepdur_sumstats_Jansenetal.txt.gz">https://ctg.cncr.nl/documents/p1651/Sleepdur_sumstats_Jansenetal.txt.gz</a>
Neuroticism	Psychiatric	329821	<a href="http://www.psy.ed.ac.uk/ccace/downloads/Luciano_2017.zip">http://www.psy.ed.ac.uk/ccace/downloads/Luciano_2017.zip</a>
Anorexia nervosa	Psychiatric	14477 (3495)	<a href="https://www.med.unc.edu/pgc/results-and-downloads">https://www.med.unc.edu/pgc/results-and-downloads</a>
Heel bone mineral density	Skeletal	394929	<a href="http://atlas.ctglab.nl/ukb2_sumstats">http://atlas.ctglab.nl/ukb2_sumstats</a>
Comparative height size at age 10	Skeletal	448718	<a href="https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults">https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults</a>
Non-cancer illness code, self-reported: osteoarthritis	Skeletal	361141 (30046)	<a href="https://www.dropbox.com">https://www.dropbox.com</a>
Sitting height	Skeletal	454934	<a href="https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults">https://cnsgenomics.com/software/gcta/#UKBiobankGWASresults</a>
Standing height	Skeletal	452264	<a href="http://geneatlas.roslin.ed.ac.uk/downloads/">http://geneatlas.roslin.ed.ac.uk/downloads/</a>
Total body BMD	Skeletal	66628	<a href="http://www.gefos.org/?q=documents">http://www.gefos.org/?q=documents</a>
Birth length	Skeletal	28459	<a href="http://egg-consortium.org/downloads/EGG-GWAS-BL.txt.gz">http://egg-consortium.org/downloads/EGG-GWAS-BL.txt.gz</a>
Estimated BMD	Skeletal	142487	<a href="http://www.gefos.org/sites/default/files/">http://www.gefos.org/sites/default/files/</a>
Height	Skeletal	49796	<a href="ftp://ftp.ebi.ac.uk/pub/databases/gwas/summary_statistics">ftp://ftp.ebi.ac.uk/pub/databases/gwas/summary_statistics</a>
Osteoarthritis	Skeletal	455221 (77052)	<a href="ftp://ftp.ebi.ac.uk/pub/databases/gwas/summary_statistics">ftp://ftp.ebi.ac.uk/pub/databases/gwas/summary_statistics</a>
Osteoarthritis of hip	Skeletal	393873 (15704)	<a href="ftp://ftp.ebi.ac.uk/pub/databases/gwas/summary_statistics">ftp://ftp.ebi.ac.uk/pub/databases/gwas/summary_statistics</a>

Supplementary Table 5. The significant TWAS results of the genes we identified in the Kia's paper.

<sup>a</sup> Gene	Chr	<sup>b</sup> P0	P1	Z-score	P-value	FDR
<i>MMRNI</i>	4	89879532	89954629	10.21	1.86×10 <sup>-24</sup>	2.52×10 <sup>-21</sup>
<i>CD38</i>	4	15778275	15853230	-9.60	7.66×10 <sup>-22</sup>	8.30×10 <sup>-19</sup>
<i>GPNMB</i>	7	23235967	23275108	8.51	1.69×10 <sup>-17</sup>	1.53×10 <sup>-14</sup>
<i>NUPL2</i>	7	23181827	23201011	8.35	7.02×10 <sup>-17</sup>	5.11×10 <sup>-14</sup>
<i>VKORC1</i>	16	31090842	31095980	5.34	9.42×10 <sup>-8</sup>	2.22×10 <sup>-5</sup>
<i>CENPV</i>	17	16342534	16353656	3.63	2.86×10 <sup>-4</sup>	0.0158
<i>RNF40</i>	16	30761745	30776307	-3.32	8.94×10 <sup>-4</sup>	0.0381

<sup>a</sup>Genes are ordered by the TWAS *P*-value in CMC dorsolateral prefrontal cortex reported by Kia and colleagues;

<sup>b</sup>Gene positions are assigned to the CRCh38 human reference genome assembly. Note: Chr, chromosome; FDR, false discovery rate.

Supplementary Figure 1. Heatmap of the associations between each SNP in the final models of the 8 identified genes and the top five phenotypes (excluding PD) identified via pheWAS.

