

# Changes in metabolic parameters in psoriatic patients treated with secukinumab

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## Abstract

**Background:** Psoriasis is associated with cardiovascular disease and metabolic syndrome but the effects of interleukin (IL)-17A inhibitor treatment on metabolic parameters are unknown. This study aimed to determine the effects of secukinumab on metabolic parameters based on the disease activity and treatment response in patients with psoriasis.

**Methods:** In this retrospective study, we included 99 patients with moderate to severe psoriasis, who received IL-17 inhibitor (secukinumab) treatment for 24 weeks between January 2016 and February 2020. The disease activity [Psoriasis Area and Severity Index (PASI)] and metabolic parameters at baseline and after 12 or 24 weeks of treatment were collected.

**Results:** The PASI improved with a significant reduction of high-sensitivity C-reactive protein (hs-CRP) at weeks 12 and 24 respectively. However, body weight and body mass index were significantly increased at week 12 and 24 of treatment. Triglycerides level and atherogenic index of plasma were significantly higher in week 24 in PASI-90 non-responders. The baseline hs-CRP level and PASI-90 non-response correlated with elevated triglyceride levels.

**Conclusion:** Our results suggest that obesity and hypertriglyceridemia still existed in patients despite the improved disease activity after secukinumab treatment. Higher baseline hs-CRP level and PASI-90 non-response were predictors for elevated triglyceride levels after treatment. Therefore, patient education, regular screening of the lipid profile, and weight control are recommended during the treatment of secukinumab.

**Keywords:** high-sensitivity C-reactive protein, metabolic syndrome, psoriasis, secukinumab, triglyceride

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## Introduction

Psoriasis is one of the most common immune-mediated disorders. It involves the interaction between different immune cells and cytokines. Among these different players, TH17 cells are characterized by the production of cytokines, including interleukin (IL)-17A, and are regarded as key players in the pathogenesis of psoriasis. IL-17A acts on different cells, including keratinocytes, neutrophils, and endothelial cells, to stimulate the production of various chemokines and pro-inflammatory cytokines. Pro-inflammatory cytokines can then migrate into the systemic

circulation, potentially resulting in endothelial dysfunction, formation of atherosclerotic plaques, and cardiovascular disease.<sup>1</sup> Therefore, psoriasis is also associated with accelerated atherosclerosis and increased risk of cardiovascular events.<sup>2–6</sup> Moreover, IL-17 is also a factor linking the pathogenesis of psoriasis with metabolic disorders and is associated with lipid metabolism, insulin resistance, and diet-induced obesity.<sup>7</sup> Metabolic syndrome also increases cardiovascular risk in the general population and is often associated with more severe forms of psoriasis.<sup>8–10</sup> Secukinumab is a fully human anti-IL-17A IgG1 monoclonal

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antibody for plaque psoriasis. However, reports of the effects of anti-IL-17A agents on metabolic parameters and cardiovascular risk are still limited. Therefore, our study aimed to determine the effects of secukinumab on metabolic parameters and obesity based on the disease activity and treatment response in patients with psoriasis.

## Methods

This study has been approved by the Institution Review Board of Chang Gung Memorial Hospital, Linkou branch (IRB no. 202000244B0). The IRB agreed to waive the informed consent because this research involves no more than minimal risk to patients and the waiver will not adversely affect the rights and welfare of the patients. A retrospective cohort study was carried out in Chang Gung Memorial Hospital, Linkou, between January 2016 and February 2020. Ninety-nine adult patients ( $\geq 18$  years old) were included in this study with the diagnosis of psoriasis for more than 1 year. Ninety-four patients had a diagnosis of moderate to severe psoriasis, which was defined as having a Psoriasis Area and Severity Index (PASI) score  $\geq 10$  or  $\geq 10\%$  of body surface area affected, that justified the use of secukinumab. Among them, 84 patients received 300 mg dose at weeks 0, 1, 2, 3 and 4 then once every 4 weeks from week 4 onward. Ten patients (10.1%) received 150 mg dose due to their lighter weight ( $\geq 60$  kg). Secukinumab was administered in five patients for the treatment of psoriatic arthritis with 150 mg dose at weeks 0, 1, 2, 3 and 4 and once every 4 weeks thereafter. Patients receiving concomitant phototherapy or concomitant systemic treatments such as methotrexate, cyclosporin, acitretin, or other biologic agents were also excluded. The presence of psoriatic arthritis was not an exclusion criterion.

The disease activity was assessed using the PASI at baseline (week 0) and week 12 and 24. The body mass index (BMI), body weight (BW), acute phase reactants [erythrocyte sedimentation rate (ESR), high-sensitivity C-reactive protein (hs-CRP)], fasting glucose, and serum lipoprotein concentrations including total cholesterol, high-density lipoprotein (HDL), low-density lipoprotein (LDL), and triglycerides (TGs), were recorded at week 0, week 12 and week 24. Lipid protein ratios reflecting cardiovascular risk (Atherogenic Index of Plasma (AIP), defined as  $\log(\text{TG}/\text{HDL})$ ), were calculated. The correlation

between changes in metabolic parameters and disease activity (PASI score, ESR, and hs-CRP) between week 0 and week 24 were assessed. The changes of metabolic parameters at week 0 and at intermediate timepoint (week 12) were also evaluated and were also stratified according to PASI-90 response at week 12 (Supplemental Material Table S1 online) or week 24 respectively. Subsequently, we compared the differences in metabolic parameters and lipoprotein ratios in PASI-90 responders at week 24 [defined as PASI score with  $\geq 90\%$  improvement (PASI-90+)] versus PASI-90 non-responders at week 24 [defined as PASI score with  $< 90\%$  improvement (PASI-90-)].

Categorical variables were assessed using the chi-square test. Quantitative variables at baseline (week 0) were analyzed using Student's *t*-test. The paired *t*-test was used to analyze metabolic parameters in patients before and after treatment. Because hs-CRP and ESR had a skewed distribution, the Wilcoxon signed rank test was used to analyze the ESR and hs-CRP in patients before and after treatment. Mann-Whitney *U* test was performed to analyze the ESR and hs-CRP at weeks 0, 12 and 24 between PASI-90+ and PASI-90-. A *p*-value less than 0.05 was considered significant. All statistical analyses were performed using SPSS v.25.0 (IBM, New York, USA).

## Results

The demographic characteristics of the subjects at baseline are described in Table 1. The mean age at treatment was 44.73 years, with an average disease duration of 17.19 years, and 75.8% of patients were men. More than 80% of patients were overweight (BMI  $> 24$  kg/m<sup>2</sup>) and almost 40% were obese (BMI  $> 30$  kg/m<sup>2</sup>). The baseline age, disease activity, and comorbidities were similar in PASI-90+ and PASI-90-; however, PASI-90- had longer disease duration, higher BW, lower proportion of biologic treatment-naïve patients, and a larger proportion of men. PASI-90- tended to have higher baseline hs-CRP and uric acid levels compared with those in PASI-90+ (Table 2).

Overall, PASI scores improved significantly over the study period from a mean value of 19.21 at week 0 to 3.79 at week 24. Fifty-three patients (53.5%) reached PASI-90 at week 12 while 39 patients (39.3%) reached PASI-90 at week 24.

**Table 1.** Demographic and clinical characteristics of 99 psoriatic patients receiving interleukin-17A blockade (secukinumab/Cosentyx®).

	All N = 99	PASI-90+ n = 39	PASI-90- n = 60	p
Age <sup>†</sup> , mean (±SD), years	44.73 (±13.15)	43.56 (±13.46)	45.48 (±13.00)	0.481
Disease duration, years	17.19 (±8.83)	14.82 (±8.65)	18.73 (±8.67)	0.031*
Sex				
Male	75 (75.8)	24 (61.5)	51 (85.0)	0.015*
Female	24 (24.2)	15 (38.5)	9 (15.0)	
BW, kg	80.33 (18.07)	74.40 (14.23)	84.18 (19.33)	0.008*
BMI, mean (±SD), kg/m <sup>2</sup>	28.92 (±5.783)	27.24 (±4.73)	30.00 (±6.25)	0.021*
<24	18 (18.2%)	12 (30.8%)	6 (10.0%)	
24–27	23 (23.2%)	8 (20.5%)	15 (25.0%)	
27–30	19 (19.2%)	7 (17.9%)	12 (20.0%)	
>30	39 (39.4%)	12 (30.8%)	27 (45.0%)	
Systemic agents-naïve	68 (68.7%)	22 (56.4%)	46 (76.7%)	0.046*
Biologics-naïve	45 (45.5%)	25 (64.1%)	20 (33.3%)	0.004*
Baseline, week 0, PASI (±SD)	19.21 (±11.09)	19.04 (±10.16)	19.31 (±11.74)	0.906
PASI (±SD), week 12	3.23 (±3.92)	1.05 (±2.08)	4.64 (±4.19)	<0.0001*
Treated, week 24, PASI (±SD)	3.79 (±4.83)	0.35 (±0.67)	6.03 (±5.05)	<0.0001*
Current smoking				
No	49 (49.5)	24 (61.5)	25 (41.7)	0.066
Yes	50 (50.5)	15 (38.5)	35 (58.3)	
Current drinking				
No	57 (57.6)	26 (66.7)	31 (51.7)	0.152
Yes	42 (42.4)	13 (33.3)	29 (48.3)	
Hypertension				
No	59 (59.6)	26 (66.7)	33 (55.0)	0.297
Yes	40 (40.4)	13 (33.3)	27 (45.0)	
Diabetes				
No	73 (73.7)	33 (84.6)	40 (66.7)	0.062
Yes	26 (26.3)	6 (15.4)	20 (33.3)	
Dyslipidemia				0.526

*(Continued)*

**Table 1.** (Continued)

	All N=99	PASI-90+ n=39	PASI-90- n=60	p
No	61 (61.6)	26 (66.7)	35 (58.3)	
Yes	38 (38.4)	13 (33.3)	25 (41.7)	
Hyperuricemia				
No	59 (59.6)	26 (66.7)	33 (55.0)	0.297
Yes	40 (40.4)	13 (33.3)	27 (45.0)	
Psoriatic arthritis				
No	53 (53.5)	22 (56.4)	31 (51.7)	0.684
Yes	46 (46.5)	17 (43.6)	29 (48.3)	
†Age at treatment. *p < 0.05 was considered statistically significant. AIP, Atherogenic Index of Plasma [AIP = log(triglyceride/high-density lipoprotein cholesterol)]; BMI, body mass index; BW, body weight; PASI, Psoriasis Area and Severity Index; SD, standard deviation.				

**Table 2.** Metabolic parameters between PASI-90+ and PASI-90- groups after interleukin-17A blockade (secukinumab/Cosentyx®) at week 0, week 12 and week 24.

	Week 0			Week 12			Week 24		
	All N=99	PASI-90+ at week 24 n=39	PASI-90- at week 24 n=60	All N=99	PASI-90+ at week 24 n=39	PASI-90- at week 24 n=60	All N=99	PASI-90+ at week 24 n=39	PASI-90- at week 24 n=60
hs-CRP (median, mg/dl)	3.7	2.3	4.4*	2.2	1.7	3.0*	2.5	1.8	3.6*
ESR (median, mm/h)	9	9	9	7	7	8	8	7	8
Sugar (mean, mg/dl)	98	101	97	103	102	104	102	103	101
UA (mean, mg/dl)	6.6	6.1	6.9*	6.3	5.9	6.5	6.4	6.1	6.5
HDL (mean, mg/dl)	44	46	43	44	46	42	44	47	43
LDL (mean, mg/dl)	114	114	113	115	113	115	113	113	113
CHOL (mean, mg/dl)	185	184	185	188	187	189	188	190	186
TG (mean, mg/dl)	134	129	137	152	138	160	152	141	159
n-HDL (mean, mg/dl)	141	140	142	145	141	147	144	144	144
AIP (mean)	0.45	0.41	0.47	0.5	0.42	0.54	0.5	0.43	0.54

The independent *t*-test was used to analyze metabolic parameters between PASI-90+ and PASI-90- at (1) week 0, (2) week 12 and (3) week 24. Mann-Whitney *U* test was used to analyze the ESR and hs-CRP between PASI-90+ and PASI-90- at (1) week 0, (2) week 12 and (3) week 24.

\**p* value was less than 0.05.

AIP, Atherogenic Index of Plasma [AIP = log(TG/HDL cholesterol)]; CHOL, cholesterol; ESR, erythrocyte sedimentation rate; HDL, high-density lipoprotein; hs-CRP, high-sensitivity C-reactive protein; LDL, low-density lipoprotein; n-HDL, non-high-density lipoprotein; PASI, Psoriasis Area and Severity Index; TG, triglyceride; UA, uric acid

**Table 3.** Changes of metabolic parameters at week 12 and week 24 after interleukin-17A blockade (secukinumab/Cosentyx®) stratified by PASI-90 response at week 24.

Week	All N=99			PASI-90+ at week 24 n=39			PASI-90- at week 24 n=60		
	Week 0	Week 12	Week 24	Week 0	Week 12	Week 24	Week 0	Week 12	Week 24
BW	80.33	81.12*	81.32*	74.40	75.66	75.76	84.18	84.66	84.94
BMI	28.92	29.19*	29.27*	27.24	27.68	27.87	30.00	30.17	30.26
hs-CRP <sup>+</sup>	3.7	2.2**	2.5*	2.3	1.7*	1.8*	4.4	3.0*	3.6
ESR <sup>+</sup>	9	7	8	9	7	7	9	8	8
Sugar	98	103*	102	101	102	103	97	104*	101
UA	6.6	6.3*	6.4*	6.1	5.9	6.1	6.9	6.5	6.5*
HDL	44	44	44	46	46	47	43	42	43
LDL	114	115	113	114	113	113	113	115	113
CHOL	185	188	188	184	187	190	185	189	186
TG	134	152*	152*	129	138	141	137	160*	159*
n-HDL	141	145	144	140	141	144	142	147	144
AIP	0.45	0.50*	0.50*	0.41	0.42	0.43	0.47	0.54*	0.54*

Mean, + median.

The paired *t*-test was used to analyze metabolic parameters (1) between week 0 and week 12, (2) between week 0 and week 24. Wilcoxon signed rank test was used to analyze the ESR and hs-CRP (1) between week 0 and week 12, (2) between week 0 and week 24.

\**p* value was less than 0.05.

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AIP, Atherogenic index of plasma (AIP = log(TG/HDL cholesterol); BMI, body mass index; BW, Body weight; CHOL, cholesterol; ESR, erythrocyte sedimentation rate; HDL, high-density lipoprotein; hs-CRP, high-sensitivity C-reactive protein; LDL, low-density lipoprotein; n-HDL, non high-density lipoprotein; PASI, Psoriasis Area and Severity Index; TG, triglyceride; UA, uric acid

As shown in Table 3, the mean BW and BMI increased significantly at week 12 and week 24. When the patients were stratified by obesity (BMI >30kg/m<sup>2</sup> or not), obese patients had a significantly higher mean PASI score at weeks 0, 12 and 24 than non-obese patients (Supplemental Table S2).

Compared with hs-CRP at week 0, hs-CRP levels declined significantly at week 12 and week 24 respectively, with a median value of 3.7 at week 0, 2.2 at week 12 and 2.5 at week 24. Compared with TG at week 0, TG levels significantly escalated from an average of 134mg/dl to 152mg/dl at week 12 and 152mg/dl at week 24. Uric acid at week 24 (mean, 6.4mg/dl) was significantly lower than that at baseline (mean, 6.6mg/dl). The AIP increased significantly from 0.45 to 0.50 after 12 weeks and to 0.50 after 24 weeks of treatment.

When the patients were stratified by PASI-90 response at week 24, hs-CRP decreased significantly at week 12 in both PASI-90+ and PASI-90-; but at week 24, the decline of hs-CRP was still significant in PASI-90+ but not in PASI-90-. A significant increase in mean TG and AIP levels at week 12 and week 24 were noted after secukinumab treatment among PASI-90-, but similar increase was not present in PASI-90+ at week 12 and week 24.

We further investigated the predictors of serum TG level change between week 0 and week 24 among patients who did not take lipid-lowering agents by using multiple linear regression analyses. As shown in Table 4, a higher baseline CRP level and PASI-90 non-response were significantly correlated with TG level elevation, whereas age, sex, BMI, smoking, and drinking were not.

**Table 4.** Predictors of serum triglyceride level difference between week 0 and week 24 after interleukin-17 blockade (secukinumab/Cosentyx®).

	Estimate	Standard error	p
Age (years)	0.118	0.597	0.843
Sex (male versus female)	-7.659	18.413	0.679
BMI (kg/m <sup>2</sup> )	-0.283	1.328	0.832
Biologics-naïve (yes versus no)	-26.601	14.210	0.065
Smoking (yes versus no)	-0.944	14.979	0.950
Drinking (yes versus no)	10.026	16.076	0.535
diabetes (yes versus no)	-31.084	17.927	0.087
Dyslipidemia (yes versus no)	15.162	16.454	0.360
Psoriatic arthritis (yes versus no)	14.662	13.459	0.280
Uric acid at week 0 (mg/dl)	0.143	4.438	0.974
hs-CRP at week 0 (mg/dl)	1.093	0.453	0.018
PASI-90 (responder or non-responder)	-30.062	14.660	0.044

BMI, body mass index; hs-CRP, high-sensitivity C-reactive protein; PASI, Psoriasis Area and Severity Index.

## Discussion

This is the first real-world study to investigate the impact of secukinumab treatment on metabolic parameters in psoriasis patients. In this study, a significant improvement in disease activity was found after 24 weeks of secukinumab treatment. PASI-90+ had a shorter disease duration, fewer previous biologic or systemic treatments, lower mean BW/BMI, and tended to be female, which were partially in concordance with findings from previous studies.<sup>11,12</sup> Moreover, BW, BMI, and serum TG and AIP levels were significantly higher at week 24 of treatment. Among these parameters, the elevation of TGs and AIP were more conspicuous in PASI-90-. The subsequent multiple linear regression analysis revealed that serum TG elevation was associated with a higher baseline hs-CRP level and PASI-90-. These findings suggest that metabolic parameters need to be regularly monitored during secukinumab treatment.

As previous studies have reported, we observed a loss of efficacy in patients receiving secukinumab at week 24. Over a half of the patients reached PASI-90 at week 12 but less than 40% of patients reached PASI-90 at week 24. Besides, in the

PASI-90- group, hs-CRP level decreased significantly at week 12 but then escalated with the loss of its significance at week 24. One previous study revealed that about 20% of patients treated with secukinumab exhibited loss of efficacy at 24–32 weeks.<sup>13</sup> Jorge *et al.* reported that a quarter of patients who achieved PASI-75 or PGA 0/1 at week 12 stopped secukinumab treatment before week 52 because of lack of efficacy.<sup>14</sup> All these results showed a similar trend, that patients lost the efficacy during secukinumab treatment.

Obesity is strongly associated with psoriasis severity and several comorbidities, including psoriatic arthritis, increased hepatic steatosis and dysregulated lipid metabolism, non-alcoholic fatty liver disease and premature cardiovascular disease.<sup>15,16</sup> Obesity is also associated with a higher disease severity and a lower response to secukinumab. Megna *et al.* found that obese patients receiving secukinumab had a significantly higher mean PASI score at week 24 than non-obese patients.<sup>17</sup> Regarding the BW change after biologic use, significant weight gain and BMI change have been reported after anti-tumor necrosis factor- $\alpha$  (anti-TNF- $\alpha$ ) treatment;<sup>18</sup> however, the evidence regarding weight change in patients



receiving secukinumab treatment was controversial. Recent studies, including one meta-analysis, showed there was no significant weight gain or increase in BMI among patients receiving IL-17 inhibitor treatment.<sup>19</sup> However, Gerdes *et al.* showed a weight decrease in patients treated with secukinumab for 52 weeks.<sup>20</sup> In contrast, our study found that BW and BMI increased after 24 weeks of secukinumab treatment. IL-17 has been shown to suppress adipogenesis through the combined effects of various transcriptional factors that regulate adipocyte differentiation.<sup>21</sup> IL-17 deficiency in mice generated diet-induced obesity and accelerated fatty tissue accumulation.<sup>22</sup> One recent study also found that food intake increases IL-17 in human blood, and IL-17 promotes a rapid increase in hypothalamic anorexigenic pro-opiomelanocortin (POMC) neuron expression and reduces food intake in mice.<sup>23</sup> According to these observations, we may hypothesize that secukinumab may affect body weight by breaking the negative feedback loop of IL-17 in hypothalamus, and by interfering with adipogenesis in peripheral fat tissue. This may explain the weight gain in our patients since secukinumab inhibits the effects of IL-17. However, understanding the real relationship between IL-17 inhibitors and obesity in patients with psoriasis needs more prospective studies.

Furthermore, patients with psoriasis were more likely to develop dyslipidemia, including hypertriglyceridemia and lower HDL levels.<sup>24-26</sup> Altered adipokines may drive disturbance of lipid metabolism in patients with psoriasis.<sup>27</sup> In the murine model, anti-IL-17A antibody led to an unchanged TG level but significantly reduced HDL and cholesterol levels.<sup>28</sup> Gerdes *et al.* demonstrated that secukinumab had a neutral effect on lipid parameters.<sup>20</sup> In the VIP-S study,<sup>29</sup> slight increases in total cholesterol and LDL were observed following secukinumab treatment, but no changes in inflammatory markers or TG levels were seen. Consistent with Gerdes' study, LDL, HDL, and total cholesterol levels remained unchanged in our study; however, the TG level increased significantly in PASI-90-, who had higher baseline hs-CRP levels than PASI-90+. On subsequent multiple linear regression analysis, elevation of serum TG strongly correlated with baseline hs-CRP levels and PASI-90- status. The possible hypothesis of TG elevation is that systemic inflammation is actually responsible for TG elevation in PASI-90-. PASI-90- had a higher hs-CRP at

weeks 0, 12 and 24 than PASI-90+ (Table 2), indicating that PASI-90- may have a stronger systemic inflammation than PASI-90+ throughout the study period. Besides, there is a tendency for an increase in serum TG in patients with psoriasis, and psoriasis is also associated with the hypertriglyceridemia in a "dose-dependent" manner, which means that the severity of psoriasis correlates with hypertriglyceridemia, from 10% increase in the odds in those with mild psoriasis to 46% in those with severe psoriasis.<sup>8</sup> Therefore, sustained systemic inflammation in PASI-90-, instead of direct pharmacologic effect from secukinumab, may be really associated with an increase of TG levels in our study. TG levels are influenced by the inflammatory status of a subject; one study in Taiwanese showed that people with some specific apolipoprotein genotypes with low baseline CRP levels had significantly lower TG levels.<sup>30</sup> Besides, psoriasis involves cytokines such as tumor necrosis factor- $\alpha$ , IL-1, and IL-6, all of which can cause an increase in hepatic very low density lipoprotein production/secretion and an increase in plasma TG.<sup>31</sup> This should act as a reminder to physicians to monitor TG levels in patients (particularly PASI-90-) receiving secukinumab, and adequate control with lipid-lowering agents might be necessary.

Thus far, studies of the relationship between IL-17 and cardiovascular diseases have produced inconsistent results. IL-17 can exhibit proatherogenic and protective cardiovascular effects. One study showed that low serum levels of IL-17 were associated with a higher risk of major cardiovascular events in Caucasian patients with acute myocardial infarction, implying that IL-17 may play a cardioprotective role in patients with a history of cardiovascular events.<sup>32</sup> However, the IL-17A/IL-17RA axis increases aortic arch inflammation during atherogenesis.<sup>33</sup> One recent study suggested inhibition of IL-17A improved vascular and myocardial function compared with that following cyclosporine or methotrexate treatment by measuring left ventricular function using echocardiography.<sup>34</sup> More studies are needed to explore the effect of anti-IL-17A agents on cardiovascular diseases.

On the other hand, AIP is a useful tool to evaluate the risk of cardiovascular diseases.<sup>35</sup> AIP has been associated with heart failure, obesity and non-alcoholic fatty liver disease,<sup>36-38</sup> all of which belong to important comorbidities of

psoriasis. One study on type 1 diabetes mellitus found an association between triglyceride-to-HDL ratio and hs-CRP level, and they hypothesize that elevated abnormal lipid profile would prompt the formation of foam cells in the arterial wall and increase the inflammatory activity.<sup>39</sup> Therefore, we infer that AIP may act as a marker to evaluate the cardio-metabolic risk in patients with psoriasis. In the present study, a high AIP value at baseline was presented in patients with psoriasis and significant elevation of AIP after secukinumab was noted in PASI-90-. Thus, we strongly suggest closer surveillance of cardiovascular disease in patients with psoriasis that show a poorer response to IL-17 inhibitor treatment.

This study has some limitations. First, we analyzed surrogate metabolic variables, such as BW, BMI, C-reactive protein, lipid profiles, and lipoprotein ratio in this study. Whether these parameters can serve as independent markers for an increased risk of cardiovascular events in patients receiving secukinumab remains uncertain. Second, there is a possibility that other confounding factors such as diet and exercise habit may affect the results. Third, the study was limited by its small sample size. In order to overcome these limitations and estimate changes in various metabolic variables during secukinumab treatment, a large-scale prospective study is needed. Last, as the control group, defined as patients receiving placebo for 24 weeks, is lacking in this study, the direct effect of IL-17 inhibitors on obesity and other metabolic parameters in psoriatic patients needs further study.

Our study highlights some important clinical implications. Longer disease duration, prior biologic or systemic agent use, and higher BW or BMI may be a hint for clinicians to predict an inferior response to secukinumab. PASI-90-tended to have higher levels of systemic inflammation, presenting as higher hs-CRP and uric acid at baseline. Despite clinical improvement after secukinumab treatment, BMI and TG levels can still increase and may be risk factors for cardiovascular diseases. Furthermore, baseline hs-CRP and PASI-90 response are two predictive factors for the elevation of TG levels. BW and lipid-related variables should therefore be closely monitored in psoriasis patients receiving secukinumab treatment. Patients with psoriasis should be routinely screened for metabolic syndrome

and treated appropriately to manage their cardio-metabolic risk.

### Conflict of interest statement

Yu-Huei Huang has conducted clinical trials or received honoraria as a consultant for Abbvie, Celgene, Janssen-Cilag Pharmaceuticals, Novartis and Pfizer Pharmaceuticals. All other authors have no conflict of interest.

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### Supplemental material

Supplemental material for this article is available online.

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